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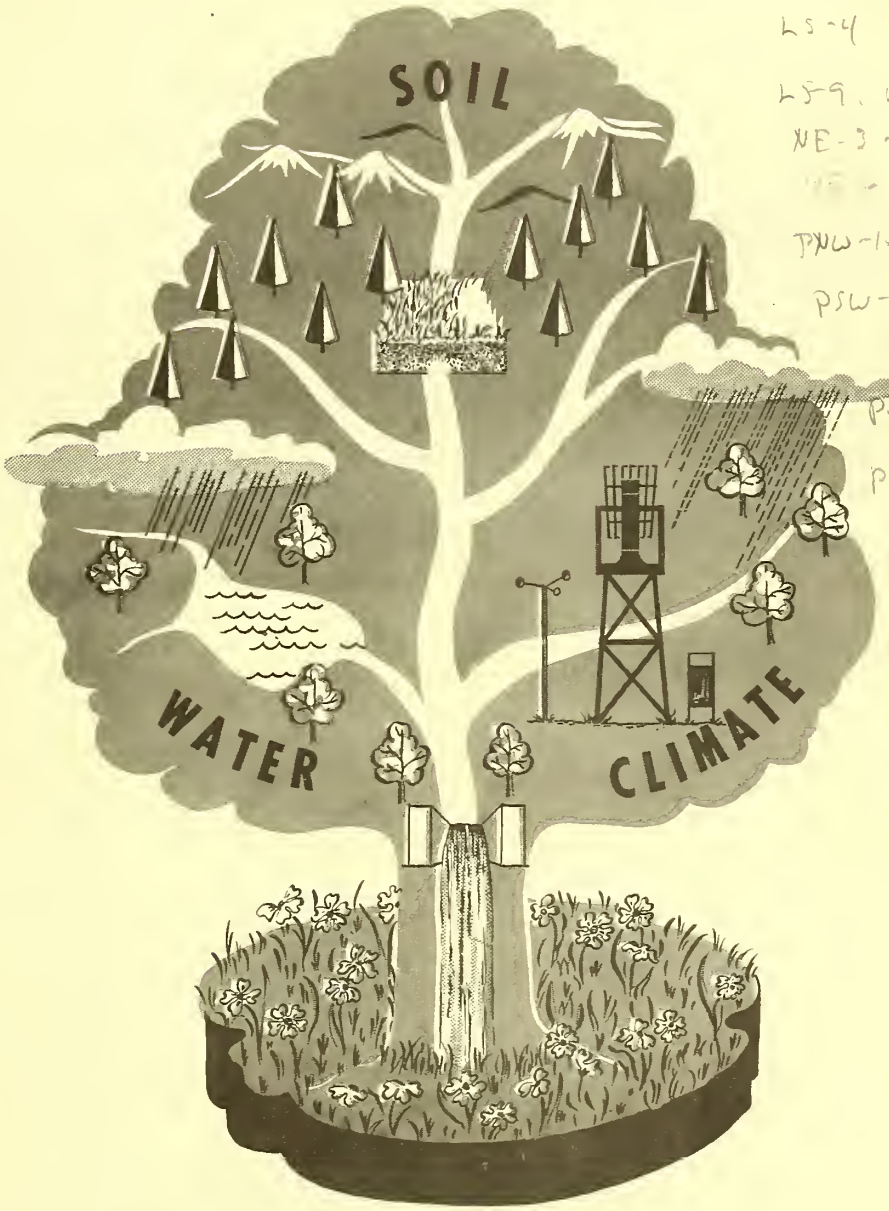
DIVISION OF
WATERSHED MANAGEMENT RESEARCH

Semiannual Report



U. S. DEPARTMENT OF AGRICULTURE - FOREST SERVICE

APRIL OCTOBER 1962

USE OF THIS REPORT

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SEMIANNUAL REPORT
Division of Watershed Management and Recreation Research
April - September 1962

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SEMIANNUAL REPORT

Division of Watershed Management Research

CENTRAL STATES FOREST EXPERIMENT STATION

April 1962 - September 1962

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April 1962 - September 1962

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SEMIANNUAL REPORT
Division of Watershed Management and Recreation Research
April - September 1962

Washington Office

Division Reorganization

Herb Storey's duties as Division Director were considerably increased recently when Forest Recreation Research, previously in the Division of Range, Wildlife Habitat and Recreation Research, was reassigned as a Branch to the reorganized Division of Watershed Management and Recreation Research. Walt Hopkins of the PSW Station has been transferred into the W.O. as Chief of the Branch of Forest Recreation Research.

Neutron Soil Moisture Handbook

The demand for this handbook has been so great we have had to reprint it. Comments from people outside the Service who have seen the handbook have been very favorable, and it has been suggested to us that it should be published for worldwide distribution. These requests make it even more imperative that the handbook receive careful review by our field people who have experience in the use of the neutron probe.

We requested Station review at the time the handbook was sent out. We want to urge that each of you with experience in use of the meter carefully review the handbook and send us your review, through your Station, by December 1, 1962. Please review it for its usefulness as an operating reference, particularly for the technician new to the field of neutron soil moisture measurement. If the reviews are favorable we will then consider revising it for publication.

Bibliography

We expect to have the biennial addition to our bibliography on Forest and Range Influences Publications to you within the near future. The Forest Service has produced about 1700 publications in this field. You fellows have been doing pretty well. The bibliographies are in four issues and are arranged by author. We are beginning preparation of a subject matter bibliography which we believe will be of more value to the users of our findings.

IUFRO Meeting

Herb Storey and Dr. Harper of the W.O. and Dr. Locke of the Forest Products Laboratory were in Ireland during the period September 5 to September 14 where they participated in a Permanent Committee and Section Leaders' meeting of the International Union of Forest Research Organizations (IUFRO). Herb is Leader of Section 11, which is concerned with watershed management and forest influences research. Dr. Harper is Vice President of IUFRO, and Dr. Locke is Leader of Section 41 (Forest Products Research). The Permanent Committee and Section Leaders meet annually between IUFRO Congresses.

Following the meeting the group took part in a four-day field trip to view Irish forestry practices and research installations. With a land area of 17,023,668 acres and a population of 2.8 million, Ireland has only 447,000 acres in forests. About 90,000 acres are in private ownership. The 357,000 acres in public ownership consist almost entirely of plantations, 50 percent of which are less than 10 years of age. The State is purchasing land and hopes to plant 25,000 acres per year until one million acres are planted. The research organization, begun in 1957 with a staff of four, currently has been increased to nine. They are primarily concerned with silvicultural, management and mensurational research. A start has also been made on investigation of the effect of afforestation on runoff.

SEMIANNUAL REPORT
Division of Watershed Management Research
Central States Forest Experiment Station

April 1962 - September 1962

I. Forest Restoration and Watershed Management on Strip Mine Lands

by Robert F. May

Since its initiation a year ago, this project has been mainly concerned with identifying the many facets of strip mine problems and making our objectives known to interested or affected parties. We feel that our working relationships with the coal mining industry, both on an individual and collective basis, are very good. The same may be said for state conservation organizations, reclamation associations, educational institutions, and other government agencies.

A. Studies

Field work on the first phase of our initial study, the determination of fluff (expansion) factor of overburden, overlying coal seams in the Harlan (Kentucky) area, is approximately 75 percent complete.

A second study, Strip Mining Effects Upon Chemical Characteristics of Water in the Forester's Creek Watershed, Harlan County, Kentucky, was initiated during June 1962. This is an exploratory study to: (1) Determine the chemical characteristics of water in the stream at non-flood stage for a one-year period; and (2) Show possible changes in water quality due to strip mining over a period of time.

When samples are processed for selected anions and cations we learned specific conductance values were most helpful in picking up components not previously analyzed. In this particular case, dissolved solids of $NaHCO_3$ were nearly 80 percent of the total. The original plan, taking samples every two weeks, has been modified because of a change in watershed conditions caused by another coal mine operator working a higher seam of coal than was anticipated and releasing some deep mine water into the watershed.

A third study was initiated in August 1962--to Evaluate Some Plant Species for Late Summer and Fall Seeding to Give a Quick Cover on Strip Mine Spoil Banks. Kentucky 31 Fescue, Balbo Rye, Italian Ryegrass, and Hairy Winter Vetch were selected for sowing at two week intervals in August, September, and October on spoil from the Harlan coal seam near Cawood, Kentucky. Suggestions for other nurse plants for acid-neutral areas and for basic soils are solicited.

Studies planned to get underway during the next 6 months include:

Erosion on Coal Haul Roads,

Fertility Evaluation of Coal Strip Mine Spoil From Certain Stratigraphic Horizons in Eastern Kentucky,

Changes in Chemical Characteristics of Coal Strip Mine Spoil Surface with Time,

Germination and Establishment of Several Nurse Crops on a Typical Spoil of Eastern Kentucky,

Seedbed Requirements for Establishing Nurse Plants on Fresh and Weathered Spoil Banks,

Pyritic Material Identification in Overburden of Certain Eastern Kentucky Coal Seams.

Our participation in the Beaver Creek administrative study with seven federal and four state agencies will continue as during the past year. Information gained from this study has provided us with excellent planning factor data for work plans designed to probe deeper into the strip mined area problem.

B. Straight Creek Experimental Area

Preliminary investigation of the 20 square mile Straight Creek Watershed in Harlan County, Kentucky, which lies north and adjacent to Pine Mountain, resulted in tentative selection of this watershed for an experimental area. It is expected that principles worked out in the laboratory at Berea can be studied under field conditions. This area would also lend itself to both applied studies and a pilot study. The pilot study is expected to be a cooperative effort with the Kentucky Reclamation Association, private coal strip mine operators, and the Kentucky Department of Conservation. Two operable seams of coal can be mined along more than 20 miles of crop line. This should permit ample pre-treatment calibration for 9 unit and 4 multiple area sampling stations. Implementation of a pilot project will necessarily depend upon the extent of cooperation and future availability of funds.

C. Cooperative Aid Studies

The strip mined area restoration project is involved in two cooperative aid studies underway with land-grant universities in the Midwest. They are:

Ohio State University - Develop methods of determining, and establish the factors which influence the structural stability of the overburden of the Lower Kittanning Coal Seam in the Ohio Valley.

Purdue University, Indiana - Determine cover type utilization by cottontail rabbit in Southern Indiana coal stripped lands.

II. Nuclear Equipment Evaluation — by Richard B. Marston

A. Duration and number of observations for measuring soil moisture with a subsurface neutron meter

Most of the information now available on the subject of the sample size that is necessary for determining a neutron soil moisture meter's impulse rate has been devoted almost entirely to a purely theoretical development of the sampling error of radioactive decay measurements. A rather strong departure of some of our empirical results from certain of the assumptions necessary in such a theoretical treatment has caused us to re-examine the error structure associated with our subsurface neutron meter observations.

The observations treated herein were taken at one point in a clay-loam soil that contained about 20 percent moisture by volume. We made 20 observations for each of nine different time periods: 1, 2, 5, 10, 20, 30, 60, 120 and 300 seconds. The probe was a Model P-19 manufactured by the Nuclear-Chicago Corporation. The results may or may not apply to other similar probes made by this or any other manufacturer.

The length of observation, measured with a stop watch, introduced a reaction-time error that increased rapidly in magnitude of impulses per minute (i.p.m.) as the observation time dropped below 60 seconds (fig. 1). The practical use of the standard deviation-time relation was found to be limited here to the durations between 10 and 300 seconds.

With two or more observations the relation shown can be used to determine the minimum length of observation required to obtain an acceptably precise estimate of i.p.m. Suppose:

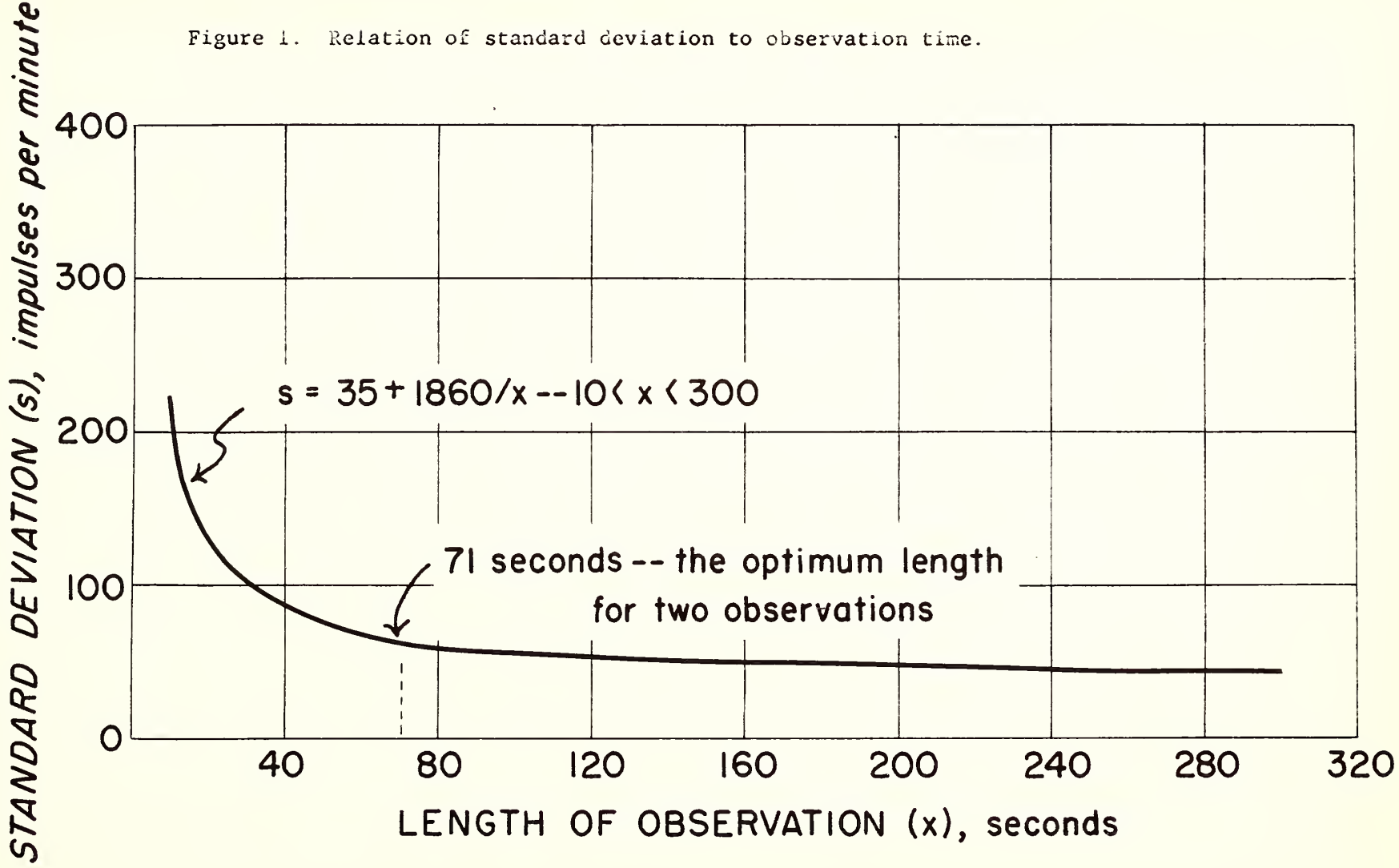
1. From experience, i.p.m. is expected to be in the neighborhood of 5500 for the soil at hand. (The i.p.m. in this study averaged about 5500. Applicability of the results to much higher or lower averages is unknown.)

2. That an allowable error or "half-confidence" interval (0.5 C.I.) of 10 percent, or 550 i.p.m., is deemed sufficiently precise for the soil-moisture estimate that is to be made.

3. That a sample size of two observations (n=2) is being considered and that measurement probability theory is applicable to impulse-rate observations of large magnitude. (The "t" value for n-1 = 1 degree of freedom is 12.706 at the 5 percent level of probability.)

Then, expressing the standard deviation (s) as a function of length of observation in seconds (X) we can substitute this

Figure 1. Relation of standard deviation to observation time.



function for s in the basic statistical equation to arrive at an estimate of the minimum length of observation period required:

$$0.5 \text{ C.I.} = ts/\sqrt{n} = t\,(35 + 1860/X)/\sqrt{n}$$

(The expression 35 = 1860/X approximates the empirical s distribution within the crucial range of 10 to 300 seconds.)

$$\text{Now, } X = 1860\,t/\left[\sqrt{n}\,(0.5 \text{ C.I.}) - 35t\right]$$
$$= 1860\,(12.706)/\left[\sqrt{2}\,(550) - 35\,(12.706)\right]$$
$$= 71 \text{ seconds}$$

Thus, with two successive and independent observations at each depth in the soil, each observation would have to be 71 seconds long in order to meet the 10 percent error limitation imposed. Considering the cost of each observation, it may be more efficient to take three or four shorter observations at each depth rather than two longer ones. Using appropriate n and t values in the above equations we obtain:

n	2	3	4
X	71	10	6

Then, three observations of 10 seconds each would total about one-fifth of the time required for two of 71 seconds each, and yet would meet the precision goal of 10 percent. The advantage of four over three is less. It is also outside the usable range of the function, s = 35 + 1860/X. Therefore, an n of 3 should be used even though it will increase the recording and computation time.

Note that X turns negative under certain combinations of formula input, indicating that the precision goal cannot be met under the circumstances imposed. Independence of sequential observations at one point is assumed here although it is probably violated to a limited extent.

B. Surface density probe

We have completed the field work for a study of the characteristics of the subsurface density probe similar to that for the subsurface moisture probe described above. The results appear to be somewhat similar, but the analysis is not yet complete enough to determine the optimum duration and number of observations that should be used. We are assuming that a similar relation will be obtained in which three short observations will be found to be desirable.

This autumn we have already made two complete sets of depth density readings on all 85 of our depth moisture access tubes. Depth moisture readings were made on each tube the same day that the density readings were made so that the wet density values could be reduced to the more common dry density terms. Therefore, at each depth, in each access tube, on two different dates, we made three 20-second readings with both the subsurface moisture and the subsurface density probes.

We have just begun to analyze this information and have found that the density readings ranged between about 6,000 and 20,000 impulses per minute (i.p.m.). According to the manufacturer's calibration chart these convert to about 20 and 164 pounds per cubic foot respectively. This suggests that our manufacturer's calibration chart of i.p.m. over density has much too flat a slope. We expected to find some variation in density but we are sure this does not represent the true range of soil density within our sample area.

Variations as high as 329 impulses (987 i.p.m. or approximately 10 pounds per cubic foot) occurred within trios of successive, 20-second readings at the same location and depth.

C. Effect of installing an automatic electric timer on a nuclear soil moisture and density scaler

Installing a new automatic electric timer on a scaler commonly used with nuclear soil moisture and density may cause as little as a 0.4 percent bias. This conclusion is drawn from our experience with one Model 2800 scaler (manual timer) which was converted to a Model 2800A (automatic electric timer) in January of 1962.

Twenty observations of regular line, alternating current on March 19, 1962, showed a preset "1 minute" time to be 59.81 seconds while the preset "2 minute" time was 119.60 seconds. According to 30 observations on July 5, 1962, these values had increased slightly to 59.84 and 119.66.

Although the bias due to the new timer is small, it is measurable even when converted to area inches of soil moisture and corrections may be desirable in some studies. For instance, some of our other studies suggest that our scaler and subsurface moisture probe will count about 5,500 impulses per minute in a moist clay-loam soil. According to our calibration curve this converts to 2.22 inches of water per foot of soil. The bias caused by the automatic timer would, on the basis of the July 5, 1962 test, amount to 0.01 inches. This is 0.4 percent of the 2.22 inches per foot of soil.

D. Alum standards for checking the calibration of neutron soil moisture meters

Amonium aluminum sulfate $NH_4\ Al(SO_4)_2 \cdot 12H_2O$ is commonly used as one of the standards for calibrating neutron soil moisture meters. The theoretical water equivalent, using only the hydrogen that is in the bound water, is 43.4 Pv (percent by volume). This is the value used by Nuclear-Chicago for their calibration standard containing alum only. We have been unable to reproduce this, however, using commercially available alum. Our barrel of alum gives only 38.2 Pv according to our subsurface P-19 probe. A possible explanation according to the Chemistry Department at Ohio State University is that our alum does not hold a full component of 12 bound water molecules.

Anyone planning to prepare standards composed wholly or partially of alum should determine the amount of bound water. This can be done gravimetrically. Theoretically a reduction to 10 bound water molecules would give 36.97 Pv. if all the hydrogen atoms were taken into consideration.

III. Subsoil Water Management — by Ronald Z. Whipkey

A. Subsurface Stormflow Studies

Rainmaker runs were continued on the plot previously reported and a new set of rainmaker-subsurface stormflow plots was initiated. We are pleased with the seemingly good relation between hydraulic conditions within the plot (as measured by multiple unit tensiometers) and outflow from the downslope troughs.

We had hoped to initiate a laboratory study of hydraulic conductivity and porosity this past summer with 3-inch and larger diameter undisturbed cores. However, spring and early summer this year were so dry that it was impossible to secure good undisturbed cores. Almost every core taken was cracked and these cracks did not seal with careful wetting and storage under humid conditions. This part of our experiment will be postponed until optimum sampling conditions are found on the experimental area.

We feel that the inherent porosity of forest soil (that related to structure and texture) is an important factor in subsurface stormflow--but we're not convinced that it is the overall contributing factor. The intrinsic permeability of soil can hardly account for the rates of flow we have measured and observed under experimental plot and actual watershed conditions.

B. Cooperation - Ohio State University

One sidelight interested us. We participated in the instrumentation of agricultural land drainage plots and some pumping tests this summer at the Ohio State University drainage experimental area near Lake Erie. The soil was fairly homogeneous compared to the soils with which we have been working. We did notice enough structural cracks and minute grass root holes at 3- to 5-foot depths to account for <u>some</u> of the "intrinsic permeability" of this agricultural soil.

Regions of blocky structure with vertical and horizontal cleavage planes more or less equal in length appeared to give the greatest rates of water movement. In breaking out some of these blocky clods, we found discoloration on the external faces, but no such discoloration inside the clods. This indicates a waterflow plane along these blocks. On the other hand, regions of extremely low permeability showed a "platy" structure with particles arranged around a horizontal plane and with mostly horizontal faces.

This was most interesting to us for it indicated that the old concept of interconnected soil cracks, root holes and channels, and bedding plane orientation may still be the best explanation for rapid movement of subsurface stormflow in forest soil.

C. Stream Gaging Station - Dover Watersheds

The plywood temporary weir on Dover Watershed No. 1 was replaced after two years of service with a concrete cutoff wall and apron. The plywood wall was in excellent condition, showing no sign of deterioration or strain, and would undoubtedly have given further dependable service.

The new weir is of standard design with a 2-foot head capacity, 90° V-notch blade. We are experimenting with an 8-foot section of 18-inch diameter terra-cotta tile for the stilling well. After six months of use we can find no fault with this type of well, but we are interested to see how it will withstand winter freezing and thawing conditions. At the present time, the glazed tile represents a significant saving in cost of material and installation.

IV. Roster of Personnel

Columbus, Ohio	Edward A. Johnson
	Richard B. Marston
	Stella A. Townsend
New Philadelphia, Ohio	Ronald Z. Whipkey
	Cecil A. Yockey
Berea, Kentucky	David G. Cummins
	Robert F. May
	*William T. Plass

*Bill Plass, a research forester, now stationed at Carbondale, Illinois, is being transferred to Berea to assist with revegetation studies.

SEMIANNUAL REPORT
Division of Watershed Management Research
Intermountain Forest and Range Experiment Station

April 1962 - September 1962

DIVISION

Activities during the past half-year have been numerous and varied. Among the more significant are the Forestry Sciences Laboratory planning and personnel changes.

The 1963 budget contains an appropriation of $300,000 for constructing the first of several stages of the Forestry Sciences Laboratory at Logan, Utah. This first stage is designed for watershed management research. It will be constructed on a site leased to the Forest Service by Utah State University. A prospectus encompassing a site development plan, project descriptions and staffing, design criteria, and equipment and power requirements has been developed.

Several personnel changes have recently occurred within the Division. Paul E. Packer was transferred from Missoula, Montana to Logan, Utah in August. Paul is now assigned as leader of the Watershed Rehabilitation and Protection project (1603). Ronald K. Tew, Soil Scientist, was employed and assigned to the Water Yield Improvement project (1605) with headquarters at Logan. Ron received his B.S. degree from Brigham Young University, his M.S. degree from Utah State University, and has completed a substantial portion of the academic requirements for the Ph.D. degree. Robert Merriam was the recipient of a Crown-Zellerbach fellowship and is pursuing graduate studies leading to the Ph.D. degree at Colorado State University under Dr. Robert Dils.

Publications

Packer, Paul E. 1962. Elevation, aspect, and cover effects on maximum snowpack water content in a western white pine forest. Forest Sci. 8: 225-235.

Numerous manuscripts are in various stages of preparation and processing. Several have been accepted for publication within the next few months.

1601 - SNOWMELT FLOOD AND SEDIMENT REDUCTION PROJECT

Road Development Guides

In 1958, theoretical consideration of the energy involved in eroding soil from road surfaces and in transporting sediment overland down slopes, resulted in the development of preliminary empirical expressions for these

two processes in terms of measurable watershed and road construction characteristics. Since then the Intermountain Station, assisted by Region 1 staff and Forest personnel, has made a detailed and comprehensive study to develop more specific erosion and sedimentation prevention criteria for use in locating and designing secondary logging roads. This was done by mathematically evaluating the previously developed empirical expressions from data obtained on 720 road study sites on national forest timber sales.

Preliminary results of this study were reported in the last Semiannual report. The study is now complete and this report presents highlights of results derived from it. They show that, in the Northern Rocky Mountain Region, road surface erosion is dominantly influenced by three watershed characteristics not readily susceptible to alteration and by two road construction characteristics that can be controlled by design and construction considerations. They also show that the distance sediment moves downslope from logging roads is controlled mainly by four watershed characteristics that are susceptible to alteration, one watershed characteristic not readily alterable, one road construction characteristic that is controllable by design, and by the age of the roads.

The fact that a majority of the factors affecting these two processes are susceptible to manipulation indicates that we can do much to improve the condition of soil and water resources following logging by proper application of the criteria resulting from this study.

Development of Criteria for Controlling Road Surface Erosion

An analysis of variance of distance which water flows down logging roads before eroding the road surface vertically to a depth of 1 inch is shown in table 1. Results from this analysis provide a basis for developing effective criteria for cross-drain spacing that controls erosion on road surfaces.

This analysis shows that the most important factor affecting distance to start of erosive cutting on road surfaces is the proportion of soil particles and water-stable aggregates greater than 2 millimeters in diameter on road surfaces. The distance to start of erosive cutting decreases as the proportion of aggregates greater than 2 millimeters in size decreases. The six soil groups studied are listed below in order of decreasing distance to start of erosive cutting and, hence, of increasing erodibility, and in order of decreasing proportion of aggregates larger than 2 millimeters in size:

1. Hard sediments (slates and shales)
2. Basalt
3. Granite
4. Glacial silt
5. Andesite
6. Loess.

Table 1.--Analysis of variance of distance of water movement down logging roads before erosive cutting greater than 1 inch in depth begins. Variance is partitioned among the watershed and road factors listed.

Source of variation	df	Partitioned sum of squares	Mean square	F	Partitioned R^2
Total	719	2,455,519.1			
Regression (20 factors)					
Road surface soil agg. > $2mm^2$	1	454,853.0	454,853.0	1/ 226.00	.1852
Road gradient	2	384,561.3	192,280.6	1/ 95.52	.1567
Topographic position	1	126,194.0	126,194.0	1/ 62.69	.0514
Aspect	1	41,783.1	41,783.1	1/ 20.76	.0170
Upper slope steepness	1	27,312.7	27,312.7	1/ 13.57	.0111
(6 factor regression)	6	1,034,704.1	172,450.7	1/ 85.67	.4214
Remaining 14 factors	14	13,750.9	982.2	2/ .49	.0056
(20 factor total regression)	20	1,048,455.0	52,422.8	1/ 26.04	.4270
Error	699	1,407,064.1	3/ 2,012.9		

1/ Significant at 1-percent level.
2/ Not significant.
3/ SE of estimated distance = 44.85 feet.

This relation has practical implication. Where soils have a low percentage of aggregates larger than 2 millimeters, the distance to start of erosive cutting and, hence, the spacing of cross drains, can be increased substantially by surfacing roads with fine gravel.

Differences in road gradient also have a substantial effect on the distance to start of erosive cutting on road surfaces. This distance is infinite at zero road gradient but becomes finite and rapidly shorter as the road gradient steepens. This relation reflects the increased abrasiveness of sediment-laden water moving down roads at higher velocities. It also indicates that no cross drainage is necessary on truly contour roads but that even a slight gradient on a road surface sets the stage for erosive cutting if the cross-drain interval is too long. A substantial reduction in the number of cross drains required can be achieved by designing roads having the gentlest grades possible.

Differences in topographic position, that is, whether a road is located in the upper, middle, or lower one-third of a sidehill slope, account for significant variance in distance to start of erosive cutting on the road

surface. This distance decreases with change of topographic position from upper to middle to lower slope position. The proportion of water-stable aggregates larger than 2 millimeters on road surfaces decreased in this same progression but the differences were not significant. Hence, the differences in distance to start of erosive cutting between topographic positions cannot safely be attributed to inherent differences in soil erodibility between topographic positions. The effect of topographic position is believed to be due to larger amounts of seepage flow emanating from road cuts onto road surfaces as the road is situated progressively further downslope. It suggests that as roads are located progressively further downslope, more stringent control measures, such as closer cross-drain spacing or gentler road grades, are necessary.

Distance to start of erosive cutting is influenced significantly by change of aspect from south-facing slopes to north-facing ones. The distance decreases with a shift from north to south aspects. The proportion of water-stable aggregates larger than 2 millimeters was slightly greater on south than on north aspects, but this difference was not statistically significant. Shorter distances to erosive cutting on south aspects, therefore, do not appear to be associated with differences in road surface soil aggregation characteristics between aspects. They are believed to be due to the combined effects of alternate freezing and thawing, which is more pronounced during early spring on bare and semibare roads on south aspects, and greater abrasive action of runoff down roads from higher snowmelt rates on south exposures. These results indicate the necessity for closer spacing of cross drains on roads built across south-facing slopes and suggest that, where a choice of aspects exists for locating a road, the north-facing aspect is the better choice--all other things equal.

The distance to start of erosive cutting on road surfaces shortens significantly as the gradient of the slope across which the roads are built decreases. This relation, at first glance, may appear contrary to expectation. Two reasons for it appear to be plausible:

1. The proportion of road surface water-stable aggregates larger than 2 millimeters in size decreased significantly with reduction of slope steepness. This suggests that shorter distances to start of erosive cutting on roads built across gentler slopes may be due, in part, to easier dislodgment and transport of the larger portions of finer soil particles and aggregates found on gentler slopes.

2. All other things equal, the total volume of precipitation and hence, the total amount of water which a watershed slope has to dispose of, is less than that which a similar but flat tract of land receives and disposes of by an amount proportional to (1— cosine of the slope angle). Support for this theoretical deduction is provided by the relation between snowpack water content and slope steepness developed by the Corps of Engineers Snow

Investigations Unit for the Central Sierra Snow Laboratory. There, the water content of the snowpack on slopes of comparable exposure decreased from 0.2 to 0.5 inch for each 1-percent increase in slope steepness. This suggests that shorter distances to start of erosive cutting on roads built across gentler slopes may reflect greater or more prolonged abrasive action of larger amounts of water emanating as seepage flow from road cuts onto road surfaces.

The important implication here is the wider spacing between cross drains permissible on roads built across steeper slopes.

Development of Criteria for Controlling Downslope Sediment Movement

An analysis of variance of distance which sediment is transported downslope from the shoulder of logging roads is shown in table 2. Results from this analysis provide a basis for developing effective criteria that define the protective width required to prevent sediment that originates on roads from reaching stream channels and lower-lying roads and other developments requiring protection.

Table 2.--Analysis of variance of distance of sediment movement downslope from the shoulder of logging roads. Variance is partitioned among the watershed and road characteristics listed.

Source of Variation	df	Partitioned sum of squares	Mean square	F	Partitioned R^2
Total	719	1,338,351.9			
Regression (24 factors)					
Obstruction spacing	2	263,561.5	131,780.8	1/ 139.86	.1970
Kind of obstruction x obstruction spacing	1	174,466.2	174,466.2	1/ 185.17	.1304
Lower slope soil aggregates > 2 mm	1	92,585.8	92,585.8	1/ 98.27	.0692
Road cross-drain spacing	1	82,287.2	82,287.2	1/ 87.34	.0615
Distance to first obstruction	1	40,763.5	40,763.5	1/ 43.26	.0305
Age of road	1	23,679.5	23,679.5	1/ 25.13	.0177
Fill slope cover density	1	4,613.3	4,613.3	1/ 4.90	.0035
(8 factor total regression)	8	681,957.0	85,244.6	1/ 90.47	.5098
Remaining 16 factors	16	1,594.1	99.6	2/ .11	.0012
(24 factor total regression)	24	683,551.1	28,481.3	1/ 30.23	.5110
Error	695	654,800.8	3/ 942.2		

1/ Significant at 1-percent level.
2/ Not significant.
3/ SE of estimated sediment movement = 30.70 feet.

This analysis shows that the most important factors affecting sediment movement distance are the spacing distance between downslope obstructions and an interaction between this spacing distance and the kind of obstructions involved. Obstructions were classified into six categories: mounds or depressions caused by windthrown trees or by trees and stumps pushed over during road construction, logs greater than 4 inches in diameter, rocks longer than 4 inches in cross-slope dimension at the ground surface, trees and stumps, slash and brush, and major herbaceous vegetation. The distance that sediment moves increases with increased spacing between obstructions and also with changes in the dominant kind of obstructions in the order in which they are listed above. This indicates that, all other things equal, narrower protective widths are permissible where closely spaced windfalls, pushovers, and larger-sized residue from logging characterize the lower slope. The widest protective widths are required where sparse, and hence widely spaced, herbaceous cover is the dominant feature of the lower slope. An important implication here is the possibility of reducing the width of protective strip required by installing effective obstructions and by intensifying the frequency of their spacing.

Reductions in the proportion of water stable soil aggregates larger than 2 millimeters in diameter on lower slopes account for significant increases in sediment movement distance. This relation probably reflects the greater transportability of smaller-sized material. The six soil groups studied are arranged below in order of decreasing proportion of aggregates larger than 2 millimeters on the lower slope and in order of increasing distance of sediment movement and, hence, of increasing width of required protective strip:

1. Basalt
2. Andesite
3. Glacial silt
4. Hard sediments
5. Granite
6. Loess.

Increases in the spacing interval between cross drains on road surfaces also account for significant increases in distance of sediment movement downslope. The width of roads did not vary sufficiently to have a large effect on the area of road supplying runoff water to each cross drain. Differences in area of road contributing runoff to cross drains resulted primarily from differences in cross-drain intervals. Increases in distance of sediment movement attributable to larger cross-drain spacing reflect larger volumes of runoff discharged downslope from the outlets of these structures.

Increases in distance from the mouth of cross drains to the first obstruction downslope on the fill or lower slope produce significant increases in distance of sediment movement. As water, often sediment laden, pours from a cross drain onto a steeper fill slope, its velocity and its kinetic energy increase rapidly. The more quickly this energy begins to be dissipated by obstructions, the less overall distance will the sediment be transported.

The distance that sediment moves downslope increases significantly as the density of ground cover on the fill slope decreases. This effect of ground cover, over and above the effect of obstructions, is attributed to the fact that (in a large proportion of instances) only a relatively few obstructions, if any, occur naturally on fill slopes. Consequently, the effect of minor herbaceous vegetation and litter evidences its influence more in the absence of obstructions than it might otherwise. This relation emphasizes the desirability of maintaining as much protective cover as possible on road fill slopes.

All of the 720 sites included in this study involved logging roads that were from 1 to 5 years old. As the age of these roads increased from 1 to 3 years, the distance of sediment movement downslope increased slightly. With further increase in age to 4 years, sediment moved a somewhat greater distance. A still further increase in age to 5 years resulted in a large increase in sediment movement distance downslope. During the course of the study, it was observed that the capacity of obstructions for trapping sediment was being reduced with increasing time since the roads were built. This relation suggests that, where the width of a protective strip is critical for sediment damage to a stream, the strip can be held to narrower widths by maintenance work to divert water from cross drains into new obstructions or by installation of new obstructions when the road is about 3 years old.

Results of this study indicate which natural characteristics of watersheds and which design characteristics of roads must receive due consideration in development of a logging road construction program that recognizes soil and water values. They also indicate which of these characteristics are susceptible to alteration and, therefore, provide leeway for control.

The quantitative relations developed from these analyses have been developed into a series of tables from which proper cross-drain spacings and protective widths can be obtained, given knowledge of the watershed and road characteristics involved. Conversely, these relations can be employed to determine the extent to which it is necessary to change an alterable watershed or road design characteristic in order to meet given protective width requirements.

These tables and instructions for their use are being developed into a guide. A manuscript covering the technical aspects of the study in greater detail is in the draft stage and will be completed soon for publication.

Paul E. Packer

Effects of Logging Roads and Timber Cutting on the Soil Mantle Hydrology in a Spruce-Fir Forest

A synopsis of this study plan was circulated to all stations in the spring of 1961. The study has since been modified to include the installation of peizometer tubes to measure permeability in the field. This required 180 pieces of 6½-foot, three-fourth-inch diameter galvanized steel pipe to be installed 3 feet from those aluminum access tubes already located 2½, 7½, 15, 25, and 60 feet uphill and downhill from the road sections.

Two methods for drilling holes to place pipe in the soil have previously been used in this study. The first method was to drill with jackhammer and hand labor only. This method proved to be too slow, since the drill bit was extremely difficult to withdraw by hand from the rocky soil. To improve production, a D-4 size crawler tractor was used to withdraw the bit with its dozer blade. This improvement doubled the average daily production.

This summer a 2-U crawler tractor (approximately D-8 size) with a jackhammer and compressor mounted on the frame, was used to drill 180 holes 5 feet deep in seven working days; an average daily drilling rate 2½ times as fast as the next fastest method used. The cost per hole was only 40 percent of the per-hole cost using a hand-operated jackhammer with dozer withdrawal.

The tractor has a boom which can extend the hammer 20 feet from the front of the tracks. The boom can also be moved side to side and up and down. There is a guide which supports the jackhammer attached to the end of the boom. An air motor acting on a chain drive within this guide can feed the drill steel into the soil and withdraw it when the hole is completed. This guide can also be lifted vertically or rotated around a horizontal axis through the end of the boom. This combination of guide and boom movements made it possible to reach many of the holes from existing roads, thereby reducing off-road travel for the machine. A large compressor mounted at the rear of the tractor frame provides ample air for the operation of jackhammer. The use of this large mechanized equipment provides an efficient means to drill holes for pipe or tube installation.

Installation of access tubes often resulted in dents or creases which would prevent the neutron probe from sliding down the tube. An ingenious device to remove these dents was designed and built by Bland Z. Richardson, a summer assistant.

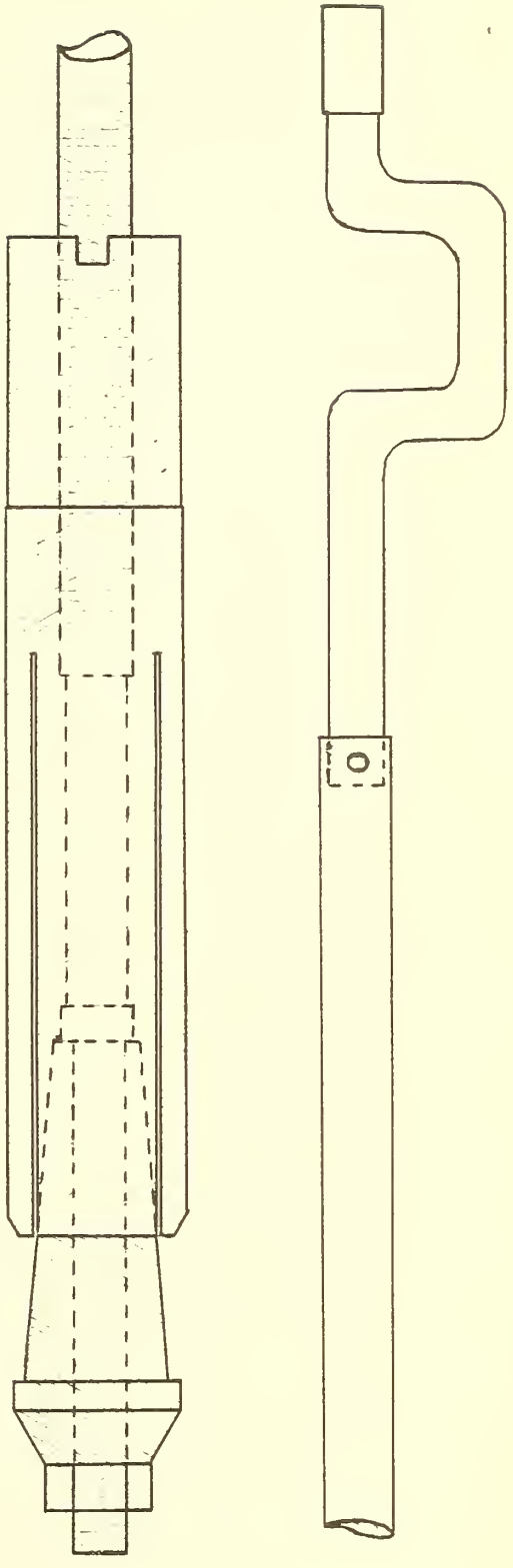
The sketch on the following page shows the slotted cylinder which will expand when the cone is forced into it by the threaded rod. The device is closed until it has a diameter slightly smaller than the inside tube diameter. It is lowered into the tube until an obstruction is felt.

The handle is turned to allow the cone to slide further out of the cylinder until the diameter is small enough to slide the cylinder opposite the obstruction. The handle is turned the other way, forcing the cone into the cylinder expanding it against the obstruction. The threaded rod is calibrated so that it is known how many turns of the rod will increase the diameter of the tube to its original size.

The expander was used to check the condition of all 360 access tubes; 41 of which had a bend or dent which prevented the probe from entering. All of the damaged tubes were quickly restored to their proper diameter by the use of this tool.

Richardson is presently working on a paper which will completely describe the tool, its manufacture, and use.

Edward R. Burroughs, Jr.



1602 - SOIL STABILIZATION PROJECT

Tailholt Creek-Circle End Creek Watersheds

A significant accomplishment this summer was the establishment of a control watershed, Circle End Creek (930 acres), companion to the Tailholt Creek watershed (1,625 acres), both of which are now undergoing calibration. These watersheds are the first of their kind to be gaged in the forested zone of southwestern Idaho.

By the same procedure used in Tailholt Creek, the volume of perennial streamflow in Circle End drainage will be determined from a rating curve by correlating the height of flow that passes through a 150-degree V-notch (concrete) weir. Upstream from the control section, bedload sand and gravel are being measured in a stilling basin designed with a 600 cu.ft. capacity after sluicing.

Calibration measurements of sediment in Tailholt Creek from the unlogged drainage basin for the past 1.6 water years are given below:

Water year	Maximum instantaneous discharge Cfs/sq.mile	Bedload sediment yield Tons/sq.mile
1961	1.80	8.9
1962 (7 months)	2.75	9.4

The snowpack this past winter and rainfall this summer were greater than for the preceding several years, hence streamflow in Tailholt Creek has remained higher and has delivered greater quantities of bedload sand into the sediment trap.

Our program to install a weighing-type precipitation recorder with temperature attachment capable of performing for long periods unattended in winter, progressed to the point where a Stevens-type Q12M recorder was purchased without temperature attachment. Leupold and Stevens discontinued the manufacture of the temperature gadget, after finding it unsatisfactory. We feel it imperative to obtain a continuous record of temperature, so we solicit your advice. Does anyone have knowledge of a factory-made thermograph complete with roll chart capable of a 60-day schedule without servicing that will run off a battery power supply?

Logging Compartment Study

This phase of the overall investigation of soil stabilization on steep slopes, now in its second year, calls for the study of five pairs of logging compartments. Each pair or unit will be installed in headwater drainages, small in size, that do not support perennial flow. The major objective is to assess the erosion damage for a period prior to road building and then for a number of years after the roads are built and the timber

harvest is completed. One-half of the compartments will be logged by the standard jammer method; the other half by a system of mobile spar-skyline crane.

In the Deep Creek unit the initial series of prelogged basins was established in 1960. Last year, two work roads were constructed across the jammer compartment. These roads contributed sediment at alarmingly high rates this spring, partly because of inadequate cross drainage and partly because of climatic conditions (see table 3). Watershed No. 1, which produced the highest yield of sediment, had the least area in roads; however, the road drainage system was such that it concentrated runoff into the channels on this watershed that has an average slope of 70 percent.

Table 3.--Sediment yields before and after logging road construction in selected drainages.

Drainage and logging method	Watershed number	Sediment yields	
		Before road construction	After road construction
		Tons/sq. mi.	
Deep Creek			
Jammer	1	0	12,416.0
	2	0	8,960.0
	3	0	89.6
Mobile spar-skyline crane	4	0	-
	5	0	-
	6	0	-
	7	0	-
	8	0	-
Oompaul Creek			
Jammer	9	0	-
	10	0	-
	11	0	-
	12	0	-
	13	0	-
Mobile spar-skyline crane	14	0	0
	15	0	0
	16	0	0

On the other hand, a very interesting situation prevailed on the Oompaul logging compartments almost 1 mile distant but at a comparable elevation. Here, a development road which traverses the mobile spar-skyline crane watersheds showed very little evidence of erosion during

snowmelt. Although it is a higher standard road with proper insloping and culvert location, its inside ditches apparently carried small amounts of runoff. Furthermore, evidence of sediment deposits below the road fill slopes and in the main channel was practically nil. Was the small amount of erosion on the Oompaul Creek road (south exposure) due to less snow? Or was it because the Oompaul road remained unfrozen while the Deep Creek roads (west exposure) were frozen under a shallow, late winter snowpack? We hope that additional observations, to be taken next spring, will determine if these local climatic conditions do prevail at the time of spring rainfall and snowmelt.

Road Fill Slope Stabilization

Our problem analysis stressed the need for the development of effective and economical methods of revegetating logging roads. To this end, a very comprehensive study was started on the fill slope of a first-season road. Fifty-six runoff plots, each 4 x 6 feet, were treated with a variety of mulches ranging from slash chips to glass fiber mats. One-half of the plots, all of which were seeded with a mixture of winter rye, sweetclover, intermediate wheatgrass, and smooth brome, will receive artificial rainfall next summer. Permanent runoff troughs will trap the soil, seed, and mulch that may be displaced. One of the supplemental watering treatments will consist of a designed high-intensity storm applied with the Intermountain infiltrometer.

An important segment of the study will be conducted by C. A. Ohlander, a graduate student at Colorado State University. By collecting samples at varying depths within the profile of a fill slope, he will characterize the physical and chemical properties of granitic road material prior to treatment and 1 year following treatment. Preliminary results indicate that bulk density of the 0-2-inch layer ranges from 1.15 to 1.54. The nonuniformity is due partly to the weight of rock material greater than 2 mm in size. This single variable is positively correlated and accounts for 59 percent of the variation. We were not surprised to find out that we are dealing with a very coarse, sandy material containing, at most, 5-percent silt and 4-percent clay.

Despite the low content of fine-textured soil materials, fresh fill slopes (inclined up to 91 percent) soon crust over and broadcast seed literally bounce off and down below onto the undisturbed forest floor. This phenomenon may be one of several reasons for the erratic establishment of grass on logging roads in central Idaho. To study this facet of the problem, boxes of soil material were moved to the lab and elevated at one end to simulate a road fill with a 70-percent slope. Seed dispersion tests were then carried out with the soil surfaces crusted and dry, wetted, "pock-marked" with shallow depressions, and covered with three kinds of mulch. Results, at this time, suggest that wetting the soil surface, spreading wetted seed instead of dry seed (similar to a Hydraseeder operation), and seeding upon mulch already in place greatly reduce seed dispersion and movement by gravity.

Harold F. Haupt
W. Joe Kidd, Jr.

1603 - WATERSHED REHABILITATION AND PROTECTION

Relation of Soil Properties and Vegetal Characteristics to Infiltration Capacity and Soil Stability

For the past 3 years a study has been under way to evaluate and determine the relations of a number of soil physical factors and plant cover conditions to infiltration and soil erosion on high-elevation range sites. During the past summer, controlled and simulated rainstorms were applied to 80 infiltrometer plots on the Davis County Experimental Watershed in northern Utah and to 86 infiltrometer plots on the Gravelly Mountains, located between the Madison and Ruby River Valleys in Montana. Study methods were essentially the same as those employed in the 1960 study in central Utah, mentioned in the October 1961-March 1962 Semiannual report, except that moisture content at 20 cm. of tension, as well as 60 cm., was determined for all soil cores. Results of this study have not yet been analyzed, but will probably be available sometime this coming winter.

It was necessary to make a large number of tension determinations in the field; consequently, a multiple-tension table, capable of accommodating 140 3-inch diameter soil cores, was built. This table consists of four plexiglass sheets, each 21 by 26 inches, supported on a wooden frame. These sheets are 1/4-inch thick with a 1/2-inch wide strip of 1/4-inch plastic cemented to the four edges to hold water on the sheets and to add strength. Plexiglass laminating cement forms a permanent weld. A short length of 1/4-inch outside diameter lucite tube is cemented in a hole in the center of the sheet. Standard size 19- by 24-inch desk blotters are used over 17- by 22-inch pieces of plastic window screen.

The wooden support is constructed of 2 by 2 uprights and 1 by 2 crossmembers and is collapsible for portability. It is 46 inches high, supporting two sheets on top and two sheets 16 inches below the top. This table proved to be rugged and dependable during the past summer and, used in conjunction with a direct-reading balance, greatly facilitated determinations of moisture contents at 20 and 60 cm. tension. The unit cost about $40.00 for materials and required about 8 hours to construct.

Richard O. Meeuwig

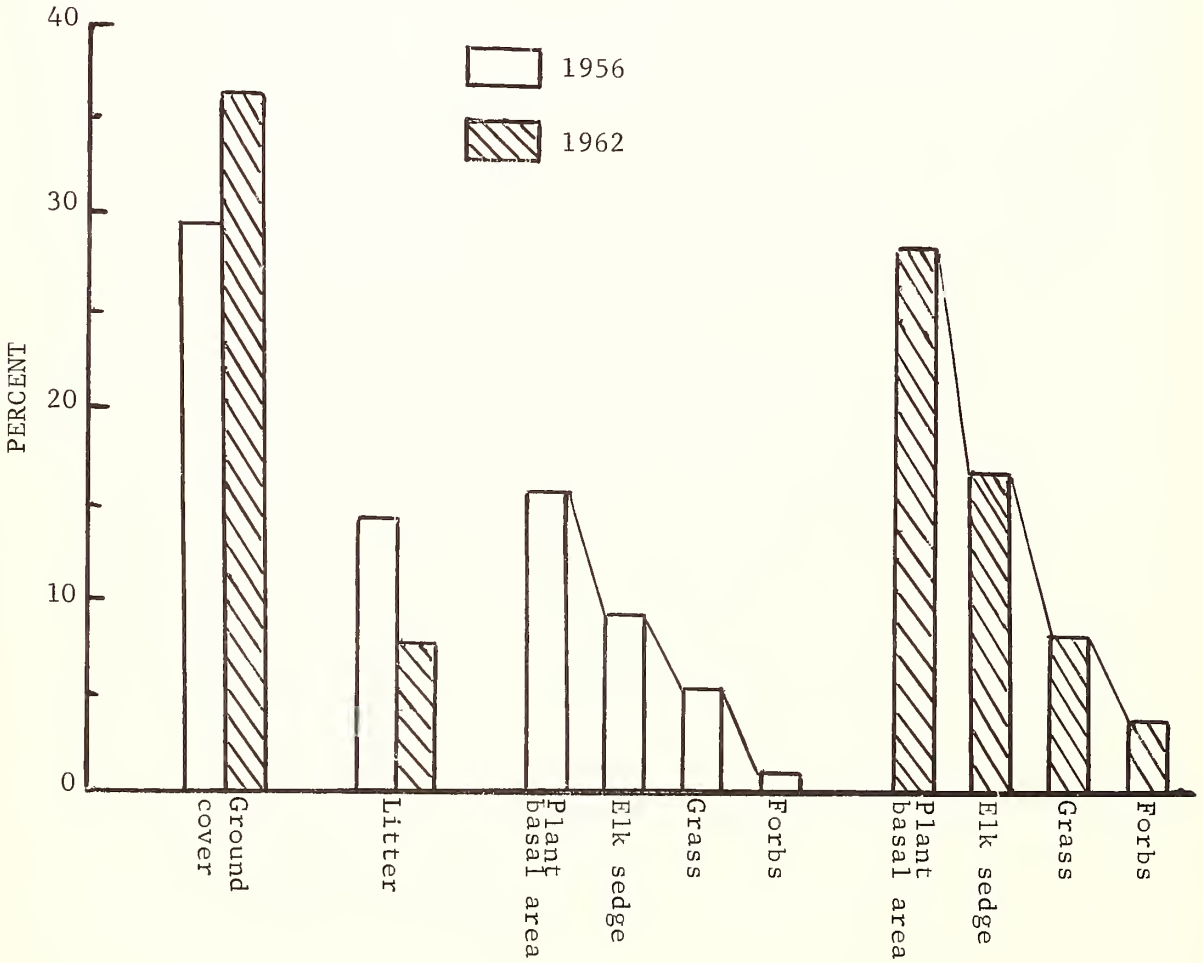
Native Plant Recovery on Open Subalpine Fir, Engelmann Spruce Slopes

In 1956 a deteriorated and flood-producing sheep range located on Morehead Mountain in the Salmon River drainage was contour trenched and retired from grazing use. As expected, the trenching treatment has been 100-percent successful in controlling overland flow and erosion.

To study the response of the native plants to protection, plots were located between trenches and remeasured biennially. This past summer's measurements of live plants and litter have now been analyzed and compared

with the 1956 data, as shown in the chart below. The chart shows an overall increase in percent of native ground cover (including plant litter) from 29.7 percent in 1956 to 36.1 percent in 1962. This improvement is attributed to a sharp increase in basal area of vegetation which includes new plants as well as enlarged older plants. On the other hand, the ground surface covered by litter has decreased unexpectedly after 6 years of protection from livestock grazing. This apparent anomaly is not unique to Morehead Mountain, but has been observed by other workers in other areas. As yet, plant ecologists have not come up with the complete answer.

Harold F. Haupt
W. Joe Kidd, Jr.



1605 - WATER YIELD IMPROVEMENT PROJECT

Functional Root Connections in Aspen Clones

Investigations of the degree to which individual stems within aspen clones remain connected after they sprout from the same root system were begun on the Davis County Experimental Watershed during the summer of 1962. Organic dyes (acid fuchsin and eosine bluish), as well as sodium arsenite, were injected into donor stems within 27 separate clones on the experimental area.

After a stem within a clone was selected as a donor, it was fitted with a frustum of a cone, and the solution to be used as a tracer of functional root connections was then poured into the frustum. The stem was girdled beneath the liquid surface and it was sawed off above the frustum. Then, a polyethylene bag was placed over the frustum and tied to the stem to reduce evaporation from the liquid reservoir and from the stem. Periodically, over the period of time during which the tracer solution was drawn downward in the donor stem and outward through roots to connected receptor stems, additional tracer solution was added to the frustum reservoir. This procedure was continued until no further receptor stems appeared.

The presence of functional connections--direct or root grafts--was detected easily because the leaves in the crowns of receptor stems turned bright red in the case of the dyes and brown when the arsenite solution was used. In addition, the arsenite-receiving receptors exhibited oozing of dark fluid from the bark and had dark streaks beneath the bark. Insufficient data are available to state which tracer was most successful for detecting connections on all sites, but it can be said that 30 receptor stems appeared from one donor injected with eosine bluish, 8 from one injection of acid fuchsin, and 17 from one of sodium arsenite. These are the maximum numbers of receptors for each tracer in this study.

Distances between donor stems and receptors varied considerably, as might be expected. The maximum along-the-ground distance was found to be nearly 60 feet in one clone in which eosine bluish dye was used. This, however, is very misleading as to the actual underground distance through which the tracer moved and is probably not a reliable index. One instance of eosine bluish movement yielded striking differences between the two measured distances. On the surface, the distance between donor and receptor was only 7.3 feet; but, when the clone was excavated, the true pathway through which the dye moved turned out to be 27.3 feet. It took 1 week for this translocation to take place.

Results from these investigations have applicability in studies of water yield improvement because they provide a better basis for understanding some of the features of aspen that must be considered when thought is given to manipulation of this species for evapotranspiration reduction.

Whether or not the sodium arsenite used in 13 clones this summer effectively killed the aspen stems and roots through which it moved can be determined only after one or more seasons have passed. If positive control of suckering is achieved by using this phytocide, perhaps progress will have been made toward solving the problem of how to reduce vegetation on some sites.

Although the effects of the soil environment upon duration of the original sucker root connections have not yet been determined, it is possible to make at least one conclusion from the study thus far. Water can be transported from one place in an aspen clone to be transpired from another place in the same clone. This fact, alone, is worthy of concern whenever water yield improvement practices take place in vegetation that is clonal in nature.

Water Use in Aspen Forest Types

The need for water in greater quantity and better quality in arid zones has prompted studies of water use by different vegetation types. Manipulation of the vegetative cover to bring about increases in water yields can proceed wisely only when adequate information exists about water use by the plants that will be manipulated and about plants that will take their place. A considerable area of higher-elevation watersheds in the Great Basin drainage area, principally above 7,000 feet, is occupied by stands of aspen, and these areas may be potential yielders of greater quantities of water than they now provide. Thus, current studies are underway to ascertain what possibilities exist for improvement of water yields by manipulation of the aspen cover on these higher watershed lands.

During the late 1940's Croft and Monninger (1953), by means of gravimetric sampling of the upper 6 feet of soil, attempted to determine the water balance under three different conditions of vegetative cover in the aspen type on the Parrish plots on the Davis County Experimental Watershed. The cover conditions studied were: aspen cover with herbaceous understory, herbaceous cover only (aspen removed), and soil completely denuded of vegetation. Results of soil moisture depletion studies during the growing season indicated that the least amount of water was lost from the bare soil, 4 inches more was lost from the purely herbaceous condition, and about 8 inches additional water was lost by evapotranspiration from the aspen-herbaceous site. These data gave rise to the popularly held belief that all that is necessary to increase water yields is to remove aspen cover from the watersheds. However, concurrent with these studies, data were obtained on the amount of soil that eroded from plots under each of the cover conditions, and it was found that the bare soil condition resulted in intolerable losses of soil.

Other water losses during the year were investigated by Croft and Monninger, including summer interception of precipitation by vegetation,

evaporation from snow, and winter transpiration. The latter two quantities were inferred from other studies and were not actually derived at the Parrish plots.

The study currently underway is a repeat of the earlier study just referred to, but this time the advent of the neutron meter for measuring soil moisture depletion and accretion has made it possible to follow the progress of water used during the growing season. Plans also call for on-the-ground measurements of snow evaporation and winter transpiration at the plots themselves. Access tubing for the neutron probe was installed on four plots of one-tenth acre each in the summer of 1961, and metering was begun on July 11, 1962. (The late date of beginning was due to operational difficulty with the metering device.)

Since July 11 the plots have been metered every 7 days. This will be continued into the approaching winter season until it is no longer possible to reach the plots which are located at an elevation of nearly 8,300 feet in the head of Parrish Canyon above Centerville, Utah.

The plot conditions are the same as in the Croft and Monninger study, with the addition of an aspen plot that was grazed by 2 sheep for 10 days in mid-July. Table 4 indicates the percentage decrease in soil water in the upper 7 feet of profile over the period from July 11 to September 19. Plot 7 is the bare soil condition, plot 8 has only an herbaceous cover, plot 9 has aspen cover and herbaceous cover that was removed completely by grazing by July 23, and plot 10 is an undisturbed aspen-herbaceous plot.

Table 4.--Decrease in total soil moisture from July 11 to September 19, 1962, Parrish plots, Davis County Experimental Watershed.

Soil profile section	Plot 7	Plot 8	Plot 9	Plot 10
Depth (feet)	- - - - - - - - - - Moisture - - - - - - - - - -			
	Percent	Percent	Percent	Percent
0-4	11.7	22.1	28.6	48.0
4-7	9.8	7.1	37.2	51.7
0-7	10.9	14.2	33.2	49.7

Percentages are given for the upper 4 feet of soil profile and for the next 3 feet because the rooting depth of the herbaceous vegetation is nearly all included in the upper 4 feet. Thus, it is apparent that most of the water loss from the herbaceous plot has come from the area of the rooting zone of the herbaceous plants. On plot 7, the bare plot, evaporation and subsurface flow probably account for the relatively small water loss. Plot

9 has lost water from the entire profile, but less has gone from the upper 4 feet than from the next 3 feet because the herbaceous vegetation was removed and has been slow to make regrowth. On plot 10, where complete vegetative cover exists, water has been withdrawn quite uniformly by vegetation throughout the profile.

Actual water loss from these plots, in the upper 7 feet of soil, from July 11 to September 19 is as follows: plot 7--2.76 inches, plot 8--3.19 inches, plot 9--6.67 inches, plot 10--9.44 inches. Although measurements were not obtained to a depth of 10 feet on all plots at the beginning of the summer, by September 19 this was being done. At that date, plot 7 had 34.76 inches of water in the 10 feet of profile. Plot 8 had 93.7 percent of that amount, plot 9 had 65.4 percent, and plot 10 had 46.2 percent. Thus, this first year of data since the Croft and Monninger study of 1947-49 would seem to indicate that a complete aspen-herbaceous cover uses a large share of the water that occurs in the soil profile in which its roots lie.

John D. Schultz

LAKE STATES FOREST EXPERIMENT STATION

Cadillac, Michigan

Udell Experimental Forest Dedicated

The Udell Experimental Forest was dedicated May 2. Main speaker for the event was Clark Holscher, WO. Other participants in the program included M. B. Dickerman, Director, LSFES; Gerald Eddy, Director, Michigan Dept. of Conservation; Louis Pommerening, Supervisor, Lower Michigan National Forest; and Dwight Spuller, Michigan Soil Conservation Districts. The dedication was held in the ski lodge of the Manistee Winter Sports Area, located within the Experimental Forest. Following the meeting, field office personnel conducted a tour of the Experimental Forest and field laboratory facilities. About 80 people attended, including many prominent in the water resource field.

Evaluating Storage Capacity from Rainfall Increments

To compute the volume of water utilized by evapotranspiration in shallow water-table areas it is necessary to weight the drop in elevation of the water table by the storage capacity of the dewatered layer. Especially difficult is the job of evaluating the storage capacity of various aquifer layers in heterogeneous material such as our lowland hardwood soils with windthrow cradle-knoll topography and mixed organic and minerals soils in the surface horizons. We have been testing a method using natural recharge by measured precipitation at times when the overburden materials are at or near field capacity. From well-level records the average gravity runoff decline expected during the storm recharge period is estimated. The sum of the rise in water table plus the normal drop due to runoff is divided by the precipitation input to yield an apparent storage coefficient for a "rewatered" layer of the aquifer. Figure 1 shows the general pattern for the lowland hardwood ground-water podzol soil mentioned above. Note that surface flooding begins about 2.5 feet below the datum plane, and the storage coefficient curve asympatically approaches 1.0 at about 1.9 feet.

Other factors which affect the above relationship have not been considered in this preliminary analysis. These include the difference in capillary rise above the new water table from that existing at the previous level, the time required for equalization of the water level within the study plot, and changes in water-table gradient during the period of accretion due to different percolation times in surrounding areas with greater or lesser overburden thickness. There

is also a variable which appears to be related to the interval between successive storms. Regardless of these other factors, the approach seems to be basically sound and offers a better method for synthesizing the various aquifer constants of the entire plot than do more limited small delivery pumping tests or the point samples used for laboratory tests. We would be happy to furnish more details if anyone is interested.

Sediment Sampling

The distribution of suspended sediment within a stream cross section is a rather complicated function involving stream velocity, channel slope, bed roughness, and other factors. In general, we can say that sediment concentrations vary both vertically and laterally. Vertical variation is generally considered to be considerably greater than lateral variation. To accurately measure the sediment discharge of a stream, both sources of variation must be considered. Vertical variation is usually accounted for by taking depth-integrated samples or by taking several point samples along the vertical, while lateral variation is accounted for by sampling at a number of verticals across the stream. Ideally, verticals should be spaced so that they represent areas of equal discharge. However, sampling in field practice rarely attains this level of accuracy. Many studies are based on single depth-integrated samples, while the automatic single-stage sampler, which takes a single sample near the surface, is increasingly being used.

During the course of our current sediment yield studies, we took a number of supplementary samples from each of our 20 sampling stations to see just how accurately our single depth-integrated samples and automatic single-stage samples estimated the mean sediment concentration of the stream. Mean sediment concentrations were determined by taking from three to seven depth-integrated samples at uniform intervals across the stream. The number of verticals sampled depended on the size of the stream and the discharge at the time of measurement.

Although considerable variation occurred between individual pairs of observations, both single samples and automatic samples were, on the average, surprisingly close to the mean sediment concentration (figs. 2 and 3). For the single depth-integrated samples, the mean for all sampling stations was eight p.p.m. higher than mean sediment concentrations, while for automatic single-stage samples it was nine p.p.m. below mean sediment concentrations. A Chi-Square test for

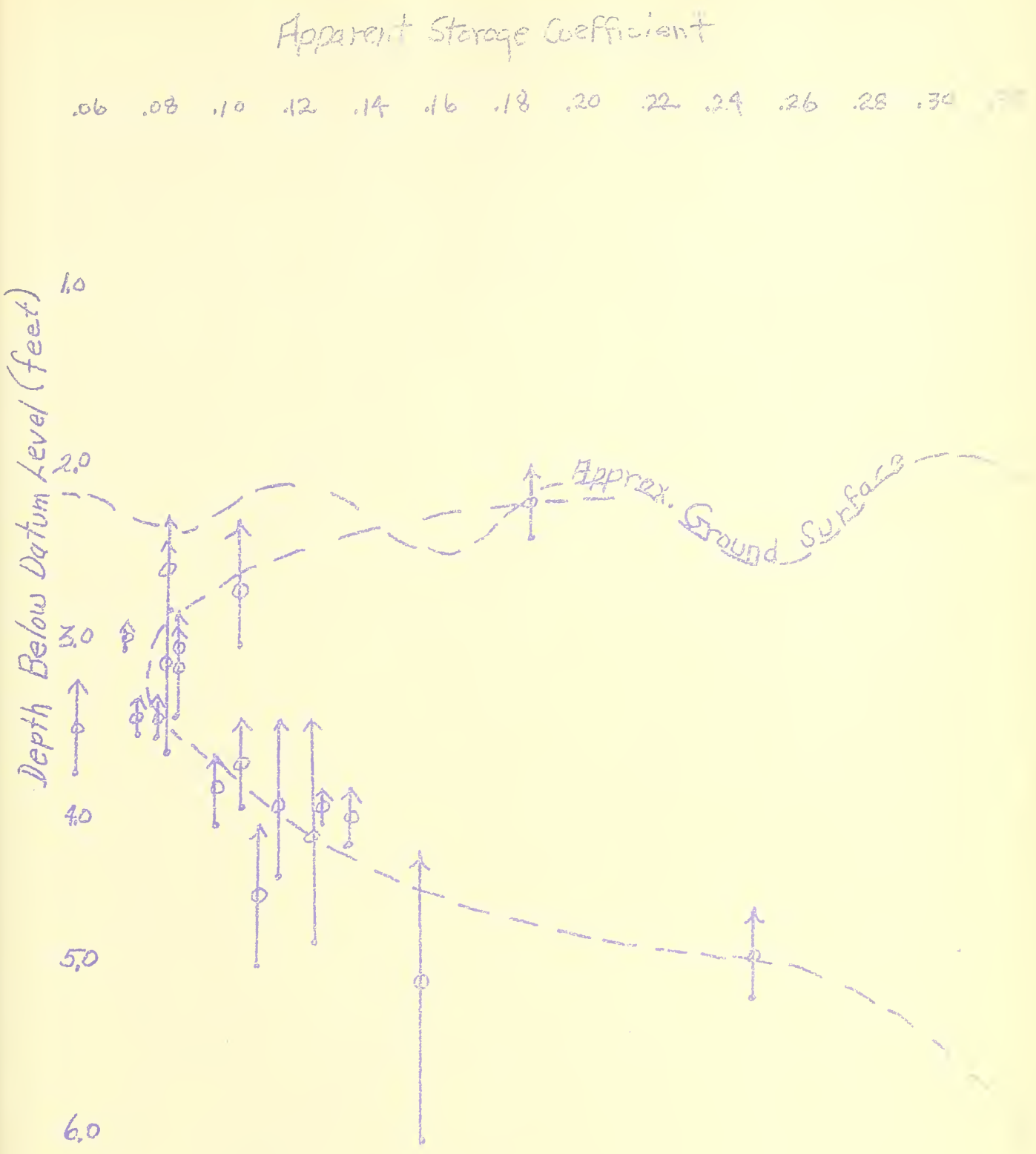

Apparent Storage Coefficient
.06
.08
.10
.12
.14
.16
.18
.20
.22
.24
.26
.28
.30
Depth Below Datum Level (feet)
1.0
2.0
3.0
4.0
5.0
6.0
Approx. Ground Surface

Figure 1

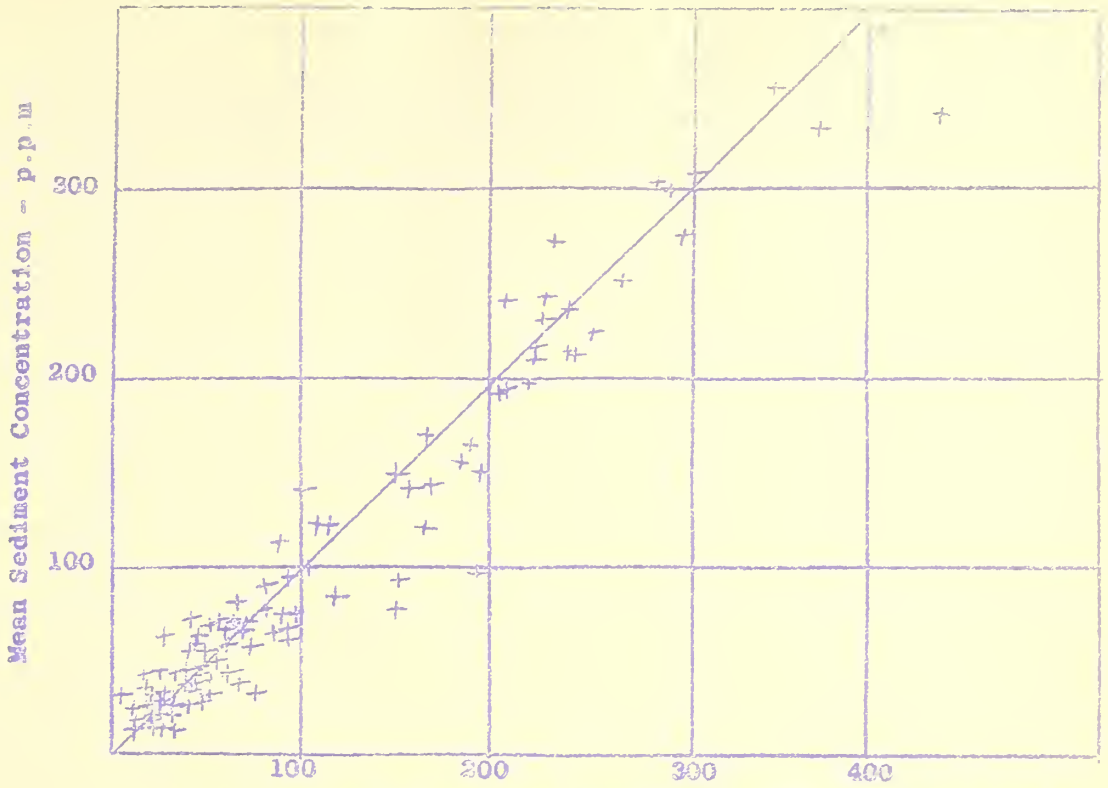


Figure 2.--Single sample sediment concentration - p.p.m.

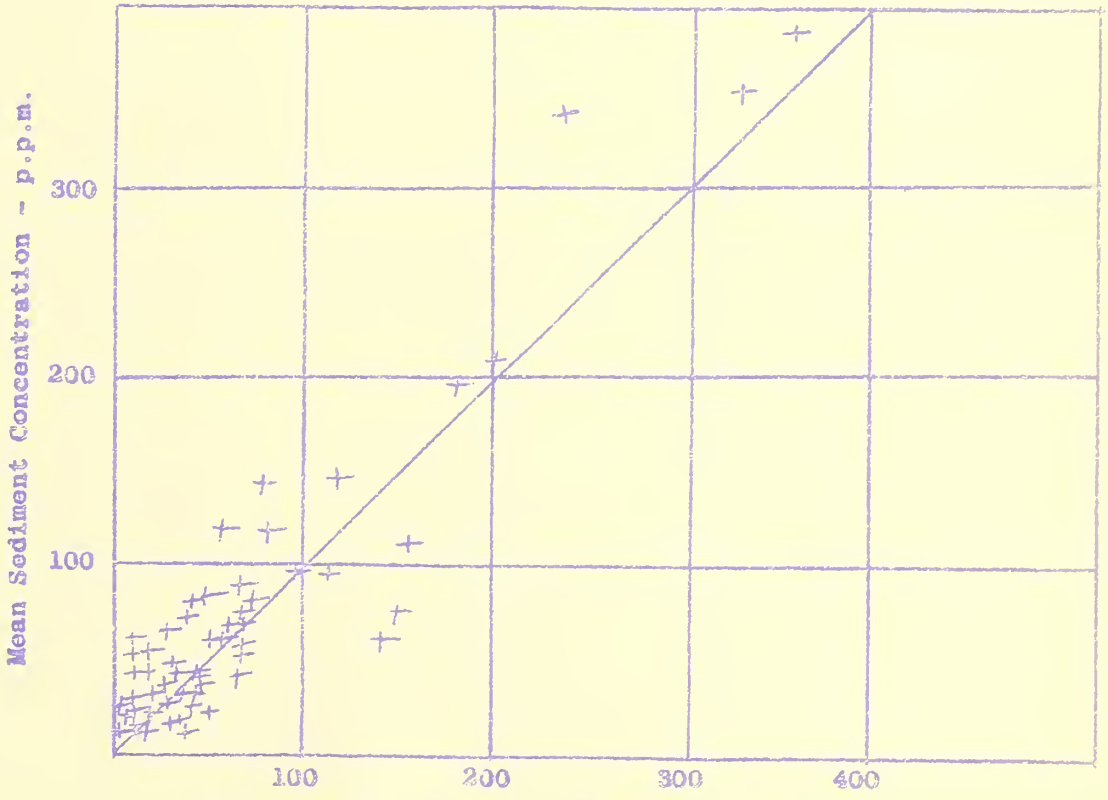


Figure 3.--Automatic sample sediment concentration - p.p.m.

accuracy shows that single depth-integrated samples and single-stage automatic samples are satisfactory measures of stream sediment concentration for the streams sampled, if the allowable error level is set at 45 p.p.m. and 50 p.p.m. respectively.

- Dave Striffler

- Dean Urie

Grand Rapids, Minnesota

General

Don Boelter either set several records or else came pretty close to doing so this past summer. Within one year after preparing his study plan on the physical properties of peat soils, he completed the fieldwork, lab analysis, data analysis, and had his Ph. D. thesis accepted. Then 5 days after receiving the degree he was already disseminating the results by giving a paper on certain aspects of the study at the national meeting of the American Society of Agronomy at Ithaca, N. Y. His paper, "Water Retention of Peats," was given a blue ribbon too.

Bog Water Tables--Some are Perched

In the past few months 1¼-inch nonrecording wells have been installed in the uplands adjacent to several of our instrumented bog watersheds. These wells are used to determine if the bog water table extended directly into the upland and the relationships, if any, that might exist between the bog water-table fluctuations and the fluctuations of the water table in the upland.

Figure 4 shows the instrumentation scheme on one of our bog watersheds. This watershed has about 12 acres of spruce swamp in the center of it. Figure 5 is a cross section through watershed S2 showing the relationship of the peat surface, peat depth, and underground water table. In this case, the bog water table did not extend into the upland. However, there was a deep underground water table about 25 feet below the surface of the peat swamp. In fact, this underground water table sloped in the opposite direction that the bog drained.

A clay till cap ranging from 8 to 12 feet thick over medium-sized sands was found in the upland area. This till cap is assumed to continue below the bog and probably is the material preventing downward movement of water from the bog. Deep soil samples from below the bog will tell us the type of soil material between the bottom of the bog and the underground water table. Hydraulic conductivity of the material will be measured to determine the rate of water movement through it. From our well records, we suspect there is little water movement below the bog. This means we have a perched bog water table and probably a pretty tight watershed.

Figure 4

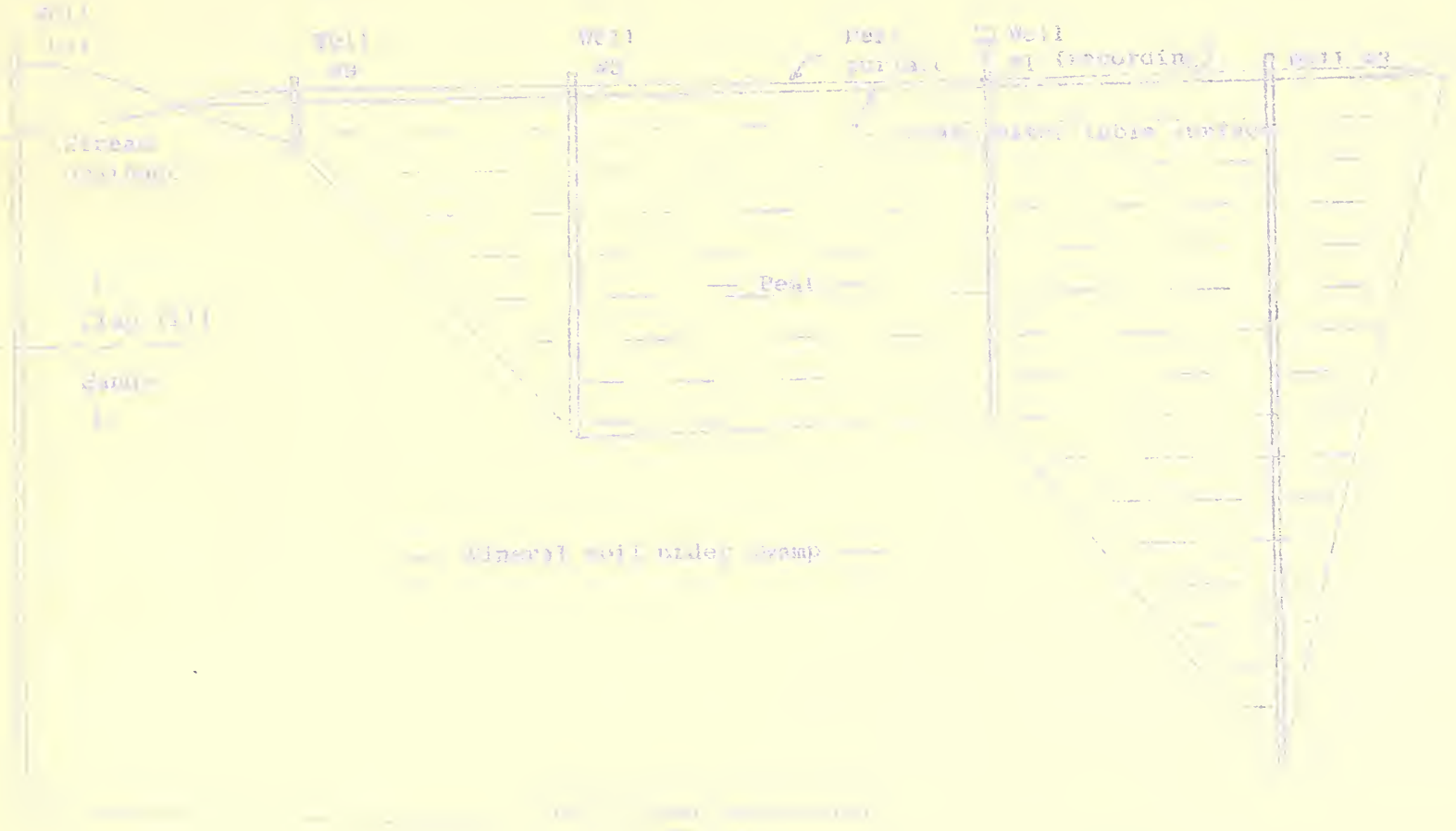


Figure 5

In other watersheds the bog water table continues into the mineral upland soils and appears to be a part of the general regional water table in the area. In these watersheds the upland soil is usually quite sandy, and little, if any, evidence of glacial till has been found.

Thus, on the basis of the extension of the swamp water table and the deep underground water table, at least two types of lake-filled bogs exist. Some of the hydrologic features of these will no doubt be quite different. Early evidence already bears this out. In the case of the perched bog water table, the water reservoir is the bog itself. When the water table extends into the upland, the water reservoir is much larger than the bog. The relative water-table fluctuations will be greater in the case of the perched water table. As a result, bog watershed calibration will probably have to be within some of these bog types.

Hydraulic Conductivity of Peats

Previous studies have shown that there are extremely large differences in the DB (wet volume basis) and structure of different peat materials; thus, it follows that the hydraulic conductivity of peats and therefore the rate of water movement through the bogs will also vary considerably. A study is now being initiated to measure both the horizontal and vertical hydraulic conductivity of these peat materials.

Piezometer and tube methods will be used for field measurements. The piezometer method consists of installing an unperforated 1¼-inch thin wall conduit and augering a 4-inch-long cavity below it. This method measures primarily horizontal hydraulic conductivity. The tube method consists of installing an unperforated tube, about 8 inches in diameter, with no cavity below the end of the tube. This measures primarily vertical hydraulic conductivity. With both methods, the rate of rise in the tube is determined and used to calculate hydraulic conductivity.

Undisturbed cores will be used to collect laboratory data. The rate of water movement through the core under a constant head will be used to calculate laboratory hydraulic conductivity. A constant head of water will be applied, using a device similar to that illustrated by Gaiser of the Central States (Technical Paper 112, published in 1949). Has anyone else tried this device, or found another which might be more useful for maintaining a constant head?

A Portable Drill for Ground Water Wells

We now have a Minuteman Mobile Drill for drilling ground water wells in the upland areas around our bog watersheds. This drill has proven to be really useful to us. It is an auger type drill mounted on a portable drilling platform which two men can wheel around. We have used it to drill holes 50 feet deep in mineral soils, and we just ordered enough auger flights to be able to drill 65 feet deep. It drills a 3-inch-diameter hole, although we have been using 1¼-inch well pipe and points for our wells.

So far, our wells have been drilled in overridden moraine country, where we have penetrated 8 to 12 feet of clay till and then an additional 40 feet of medium sand. Through this type of material, we have been able to drill 50 feet in 1 to 1½ hours, unless large rocks necessitate moving the drill.

The drill and complete outfit, including 50 feet of drill flights, several types of drill bits, and all the tools necessary to do a complete drilling job, came to slightly over $2,000. It really meets our needs for exploring the surface geology and for installing 50- to 65-foot ground water wells.

- Don H. Boelter

- Roger R. Bay

La Crosse, Wisconsin

Ground Water--Where Is It?

Flow from a number of springs on the Coulee Experimental Forest is being measured, the main objective of which is to determine the relationship of land use to ground water discharge. The springs fall into two classifications, depending upon elevational location. The upper level springs (approximate elevation 1,030 feet) are "contact springs" which appear in definite channels at the zone of contact of sandstone and an impermeable layer of siltstone. The lower level springs occur at approximately 900 feet elevation and are locally termed "sidehill springs" because they appear on sides of hills or points of ridges with no apparent relationship of drainage area to topographic features.

Hydrographs from the springs indicate that the discharge from the contact springs is quite uniform throughout the year, with no seasonal variations, while the sidehill springs fluctuate in relation to such climatic factors as precipitation and atmospheric pressure, with seasonal variations quite pronounced.

We are currently attempting to delineate drainage areas of the springs by drilling observational wells and mapping the water table. Ground water divides will be projected vertically to the land surface so we can define the "watershed" boundaries.

To date, 22 wells have been completed: 8 at approximately 25 feet above a spring, 3 at approximately 50 feet above the spring, 10 at 75 feet above the spring, and 1 at 100 feet above the spring.

Little time has been spent on data analysis so far, but indications are that the ground water conditions here are very complex. For instance, on September 12, at the 75-foot level, one well showed the water table at 10.57 feet, and another well 200 feet away on the same contour showed a 9.52-foot water level. Halfway between these two wells the water table was at minus 6.49 feet. These figures were computed from an assumed spring elevation of zero feet. The range in ground water levels within the network of wells on September 12 was from 46.73 feet to a minus 11.20 level. A more intensive survey may be warranted to determine the cause and/or effect of the "minus" water levels within the drainage system.

Watershed Instrumentation

Interested in the flow of small springs or seeps? Try a regular domestic household water meter. We bought one for $25 from the city water department and have used it successfully to determine uniformity of flow from a small spring. We took weekly readings, but you could take them at any time interval--days, hours, minutes. (Note to Whipkey: might have possibilities for measuring seepage flows in your area.)

We have devised a stage sediment sampler for use with flumes that may be of interest. We eliminated the big bends of copper tubing of the USGS models by using a float valve inside the sampler bottle. We have used two sizes of floats: 3/8 and 5/8 inch. The smaller one is a plastic bead (ladies' neckwear); the larger one, a fisherman's bobber.

We drilled a recess in the bottom of the bottle stopper at the air discharge hole to receive the float and seal the outlet when the bottle is filled. The discharge vent has a 4- to 5-inch length of tubing, curved to prevent catching rain. The intake hole has a 3- to 4-inch piece of straight tubing. Holes are drilled in the flume at appropriate stages. Short pieces of tubing are soldered in place. Koroseal flexible tubing connects flume discharge tubing with sediment bottle intake tubing.

The main weak point is that the recesses that we drilled in the rubber bottle stoppers are not smooth enough to provide a tight seal with the floats. Water leaks through the valve after it is in the closed position. We are currently negotiating with a rubber company for specially molded stoppers.

Rainfall Distribution on Coulee Experimental Forest

As the result of a special rainfall study (reported in the last Semiannual), we established a permanent rain gage network of nine gages to determine rainfall on a number of watersheds spread over a 4-square-mile area. Four of the gages are in valley bottoms, the other five just off ridgetops. Difference in elevation between valley and ridge is about 400 feet.

This season's catch from eight of the nine gages is given below (the ninth gage wasn't installed until the end of July).

	Valley gages				Ridgetop gages			
Gage number	1	2	6	8	3	4	7	9
Total catch	19.03	20.40	19.67	20.64	20.25	20.24	19.74	20.64

Most of the difference comes from a few individual storms.

As a matter of curiosity, we set up one of our 12-inch-high rain gages beside a standard WB gage. Both have standard 8-inch WB funnels, and plastic bottle collectors. Total catches for the period were 19.74 inches for the standard, 19.88 inches for the "shorty."

- Richard S. Sartz

- Willie R. Curtis

Forest Planting Studies

Rehabilitation studies in forest planting begun in the spring of 1961 on the Coulee Experimental Forest were continued and expanded in 1962, when an additional 14,550 trees were planted on 4 major plots, involving 223 subplots of 50 or 100 trees each. These studies involved 5 ground preparation methods, 5 age classes, 10 species, 2 transpiration retardants, 2 shading methods, and 4 types of sites.

Strong contrasts are appearing in survival (range 38 to 100 percent based on a partial sample), especially on one plot involving a droughty, steep, rocky, southeast exposure. These are problem-area stands of bluestem prairie (Andropogon) designated as "goat prairies" or "goat pastures" by local foresters and ecologists. Their steepness (53 to 55 percent) and high rock content prohibit any mechanical ground preparation, so expensive hand methods must be used. Additional studies aimed at lowering costs seem warranted.

Elsewhere, the solution of the rehabilitation problem on moderately steep, abandoned pastures and old fields hinges largely on good ground preparation, adequate age class, proper selection of tree species, and, in limited cases, proper aftercare by weeding and brush cutting.

- J. H. Stoeckeler

NORTHEASTERN FOREST EXPERIMENT STATION

Division of Watershed Management Research

Semi-annual Report October 1962

GENERAL

In June we had a watershed research conference at Laconia on collection and compilation of streamflow records to compare our point-picking handicraft with recently developed machine procedures. Ron Hibbert came up from Coweeta to present their experience. Other visitors were Station statisticians, equipment salesmen, and watershed professors. A Station publication will give our conclusions: suffice it, we found some difficulty relating our effort to the Space Age.

In another general project, some time was spent in assembling information on the forest, soil, and climate for a forest atlas of the Northeast, pursuing the feeling that extension of our research results to ungaged areas away from the Fernow or Hubbard Brook demands something more than a hopeful guess. Towards that same end, Reinhart plans to impose Thornthwaite's procedures on Fernow data and check predicted water surplus and potential ET against measured values, and Bill Sopper at Penn State is analyzing USGS streamflow records in the Northeast for similarities and differences by physiographic regions.

The Hubbard Brook people soon plan to move out of their trailer into a new office building that overlooks one of the best views in the White Mountains. At Parsons, Watershed will share next year a new lab-office with Forest Management. These will shelter, we can hope, new ideas.

FERNOW EXPERIMENTAL FOREST

Publications, meetings, and conferences--in addition to routine record collection and compilation--accounted for a major part of our effort in this period.

In May we reviewed our watershed program with Lull. Plans are to start treatment of forested Watersheds 6 and 7 in 1963. Each watershed will be clearcut in two steps followed by application of silvicides. Tentative plans call for treatment of openland Watersheds 8 and 9, starting in 1965, to determine effects of reforestation on streamflow. A big job still remaining is the calibration analysis on these two watersheds. No major new studies are planned for the

next year. At the same conference, initial planning was undertaken on the new Parsons laboratory; Bob Pierce of Laconia helped out on this.

Following a conference at Laconia on method of compiling streamflow records, we looked into the basis and accuracy of the procedure we use for determining maximum permissible rise before making a break in the hydrograph (in conjunction with the point-picking method). The results of this study will be reproduced and distributed.

With publication of a paper in the Journal of Geophysical Research and a Station Paper (in press), the major results of the study of effects of forest practices on streamflow have been recorded. We are still studying the same records because we are sure there are many possibilities for extracting additional results of value.

Reinhart attended the annual meeting of the Soil Science Society of America at Cornell in August and presented a paper: Approximating soil-moisture storage in the experimental watershed using streamgaging records. He also attended the West Virginia Inter-Agency Forestry and Wildlife Conference in May and gave a talk, Hydrologic effects of forests on small watersheds.

--Ken Reinhart

HUBBARD BROOK EXPERIMENTAL FOREST

Stream-gaging Stations

The 6th and last in one group of gaged watersheds, all of which are contiguously nested in a compact area, was completed this summer. The 6 watersheds range in size from 29 to 105 acres, have a generally southeast aspect, and are quite uniform in cover, slope, soils, and geology. A further feature of these watersheds is that the soils are entirely glacial drift plastered on relatively smooth, unweathered, essentially deep-seepage free, granite and gneiss bedrock--perfect for studying large natural lysimeters. The gaging station at #6 is a combined one-foot-high 90° v-notch with a 7 x 8-foot basin, and a 2-foot-wide San Dimas flume. Total construction cost was $2,000.

The next set of watersheds to be gaged (construction is anticipated in 1963) will be on north-facing slopes, also contiguous, but larger in size--about 170 acres. Spur roads are being built to the gaging sites now.

Our combined v-notch weir and San Dimas flume has so far performed equally as well, if not better, than the single large basin

and v-notch. The smaller basin can be covered in winter, and with a floating gas heater keep the area around the blade free of ice. Some icing developed in the flume, but we feel this can be licked by also enclosing the flume and installing a small heater.

--Bob Pierce

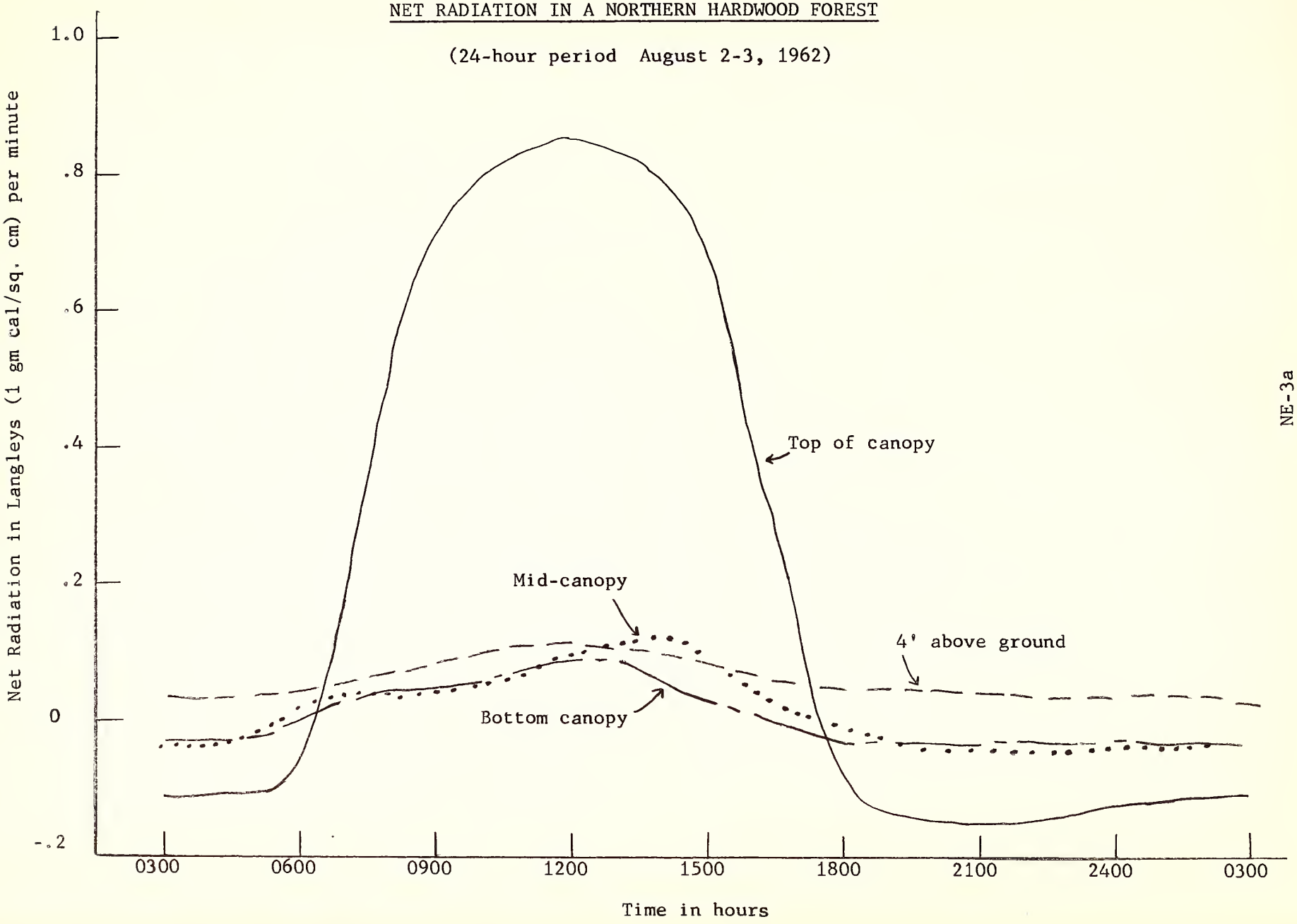
Microclimatic Study

Microclimatic studies in a northern hardwood forest got under way this summer at Hubbard Brook. A 72-foot steel tower was erected of lightweight (30 lb./section) scaffolding leased from a local firm. The 4 x 7-foot rectangular shape with built-in ladder facilitated climbing as well as mounting and reading instruments. The light-weight sections were easily carried to the site, and set up by two men. Screw jacks on each leg were used to level it on uneven ground. The tower was guyed to the ground on the four corners at six levels with 1/4-inch guy wire. A favorable feature of the tower is that it can be erected at almost any point, and made to pass through the canopy without cutting or damaging the tree branches.

Measurements of solar radiation, air temperature, and relative evaporation were taken at 30-minute intervals for 24-hour periods at five levels in the forest canopy. Approximately 10 days were sampled in August and September. Solar radiation was measured with the "Poorman's" net radiometer sensing heads wired to Goodell's Pinball counters. Air temperature was measured with shielded thermocouples, and relative evaporation was taken with Bellani black plate atmometers. The carload of data taken for these few short runs will be analyzed this winter. A few points of interest have come to light in a cursory examination. Figure 1 illustrates the wide difference in net radiation above the hardwood canopy with radiation at points 4 feet above the ground, bottom of the canopy, and mid-canopy.

Air temperature appears to be the same at all levels below the top of the canopy between midnight and one hour prior to sunrise on cloudless nights.

The tower afforded the opportunity to dispel a common belief--that the top of the canopy is a fairly uniform surface. It is not. Tremendous variations exist in total tree height, level of individual crowns, mosaic arrangement of adjacent branches, orientation of leaf surfaces, and canopy microtopography. It seems likely that such canopy microrelief would play an extremely important role in the transpiration of forest stands. Perhaps this is one area our


NET RADIATION IN A NORTHERN HARDWOOD FOREST
(24-hour period August 2-3, 1962)
Net Radiation in Langleys (1 gm cal/sq. cm) per minute
1.0
.8
.6
.4
.2
0
-.2
Top of canopy
Mid-canopy
4' above ground
Bottom canopy
0300
0600
0900
1200
1500
1800
2100
2400
0300
Time in hours
NE-3a

research has neglected.

--Ray Leonard

Miscellaneous

Progress is being made on our new field quarters at Hubbard Brook. The building, a 2-story, 30 x 60-foot structure should be ready for occupancy by Christmas.

George Hart returned for a short-lived "summer vacation" from the University of Michigan, but all too soon had to pack his bags and leave for another year at the books. This school year should wind up his residence requirements for a PhD--his major is forest hydrology.

NEW LISBON

Rainfall was seriously deficient this past growing season: the Newark and Baltimore watersheds suffered a drought throughout the whole period and the Penn State area received even less rainfall. Many of the experimental watersheds stopped flowing and others recorded the lowest flows of record.

Water-Contamination Study

At many of the municipal watersheds in the Northeast streambank and reservoir-shore vegetation is controlled by chemicals. This has bothered water-supply chemists, who are fearful of contamination. The phenoxy herbicides such as 2,4-D and 2,4,5,-T have been particularly disfavored, because chlorophenol imparts a medicinal taste to drinking water. The literature contains a large amount of data on the taste and odor thresholds of the chlorophenols, but the contaminating effects of the phenoxy herbicides are not known. Chemists have contended that the breakdown products of the phenoxy herbicides were the various chlorophenols, but a recent study showed that bacterial action in soils resulted in their decomposition to carbon dioxide, inorganic chlorides, and water.

As foresters generally prefer phenoxy herbicides a study was devised to determine their possible contaminating effects.

Two small streams were chosen, on the Newark watershed and on Penn State's Stone Valley Forest, and the riparian vegetation was sprayed, using a mistblower. On one stream 2,4,5-T in oil-water emulsion was used, while the vegetation along the other stream received an application of an emulsifiable acid of 2,4,5-T (no oil carrier in the concentrate or in the diluting material). About 1,000 lineal feet of stream was treated at each replication, with about 20 feet of application on each side. Water samples were

taken immediately before and after spraying and periodically thereafter.

Testing the samples for contamination was the most difficult part of the study. Chemical procedures were available, but not for the very low concentrations around the taste and odor threshold. Of course very large samples could have been taken, to be concentrated later for chemical analysis; but the large samples required--about 10 gallons--would have made the testing very expensive and the transporation problem insurmountable.

The alternative method to chemical analysis was the use of taste and odor panels. Robert P. Baker, a chemist at the Franklin Institute in Philadelphia, had recently made a comprehensive study on taste and odor testing and had concluded that the human nose was the best apparatus for detecting undesirable odors.

Of the two panels set up, one at Penn State and the other at New Lisbon, the former delivered the more sensitive and consistent results. To date we have learned that there was a small amount of contamination immediately after spraying. A slight amount was found after the first large rain. No contamination was ever found in a downstream sample, in which dilution had occurred. There is some evidence that chlorination oxidizes and eliminates the contaminating substances rather than accentuating the odor of it. The herbicide seems to decompose in raw water (which always has a certain organic content), so that reservoir storage would have a purifying effect on contamination if it occurred.

Bill Sopper of Penn State and Roy Johnson of Amchem, Inc., are cooperators in this study.

Other Field Work

As noted in recent semi-annual reports, the concrete weir boxes at our cooperative projects are beginning to leak. Leaks developed in two of the three concrete weirs at the Newark watershed. One was sealed with bentonite but the same treatment was unsuccessful at the other weir. The latter was lined with vinyl plastic in August.

One of the two concrete weirs at the Baltimore watershed was lined last summer. The other one is now leaking and will be lined next month.

The wooden flume installed last summer at Penn State was lined with vinyl plastic. This appears to have been a mistake, as the plastic shrinks in cool temperatures and pulls away from the wood in the corners. The stretched plastic with no firm backing was

vulnerable to punctures last winter and needed repairs this summer. Even after repair, the shrinking continued and the lining will probably be punctured again this winter. Instead of the plastic liner, an asphalt membrane should have been applied to those areas where leakage would occur--primarily the corners where the walls meet the floor of the flume and the approach box.

Soil Moisture and Bulk Density Variation

Some results from the soil-moisture study at the Lebanon Experimental Forest were presented at the annual meeting of the Soil Science Society of America at Cornell in a paper by Irv Reigner and John Phillips, Variations in bulk density and moisture content within and between closely-spaced plots in Lakeland and Lakehurst sands.

--Irv Reigner

SYRACUSE

Preliminary analyses of 50-years of streamflow record for a five hundred square-mile drainage area in the Adirondacks indicates that there has been a definite decrease in total streamflow during the dormant season. This occurred over a period when the State of New York was acquiring approximately three-fourths of the land in the watershed. Exclusion of fire and cutting on this land is inferred to have resulted in increased forest density and some change in composition. A detailed study of the vegetation history is being made.

Growing season decreases in streamflow were insignificant, but use of an estimate of average watershed precipitation, instead of the single station precipitation record used as an index, may remove some of the variation in the multiple regression which is obscuring a significant effect.

--Art Eschner

PUBLICATIONS

Effect on streamflow of four different forest practices in the Allegheny Mountains. K. G. Reinhart and A. R. Eschner. Jour. Geophys. Research 67: 2433-2445.

Manuscripts Submitted

Leaf fall, humus depth, and soil frost in a northern hardwood forest. George Hart, Raymond Leonard, and Robert Pierce.

Forest influences by questionnaire. Howard W. Lull.

Approximating soil-moisture storage in the experimental watershed using streamgaging records. K. G. Reinhart.

Some observations on precipitation measurements on forested experimental watersheds. Raymond Leonard and Kenneth G. Reinhart.

Proceedings of the watershed management research conference on collection and compilation of streamflow records. Watershed research staff.

Some relationships among air, snow, and soil temperatures and soil frost. George Hart and Howard W. Lull.

PACIFIC NORTHWEST FOREST AND RANGE
EXPERIMENT STATION

Semiannual Report
Watershed Management Research

April 1 - September 30, 1962

GENERAL

Construction on the new laboratory at Wenatchee is coming along well, after an irksome strike in June. The name is official now - Forest Hydrology Laboratory, Pacific Northwest Forest & Range Experiment Station.

During the planning phase of the laboratory project, we learned quite a few things which should be helpful to others who have laboratory planning jobs ahead of them. For example, we think we know more than we did 6 months ago about provisions for use of radioactive materials. In another year we might begin to understand what we know, and perhaps have our minds changed on a few things, too.

We have already had some laboratory visitors. In early September, Ray Rice, Bob Crouse, Sam Krammes, and Larry Hill from the PSW Station stopped at Corvallis, Portland, and Wenatchee. Their visit was stimulating, and we very much enjoyed the opportunity to toss a few ideas back and forth.

Within the past 6 months we have added a new member to our crew. He is Bill Lopushinsky, who comes to us with a Ph. D in plant physiology from Duke University. Bill is assigned to the Wenatchee project but is temporarily stationed at Corvallis.

CORVALLIS, OREGON

General

After borrowing office space on the Oregon State University campus, we have finally settled into an office and office-laboratory in the new Forestry Sciences Laboratory, 3200 Jefferson Way. This building is on the west edge of the present campus, but will soon be surrounded by a new Forestry School building and several other research laboratories. Facilities of the University are still conveniently available to us.

Bill Lopushinsky, Plant Physiologist from Duke University, is temporarily sharing the laboratory with Ted Dyrness. He will be with us until the Wenatchee Laboratory is finished. In the meantime, he is becoming acquainted with Forest Service personnel and the numerous problems involved in watershed management research in the Pacific Northwest. In addition to starting his own studies of water movement through tree roots, he is teaching an advanced plant physiology course on the campus, in which he is covering water relations of plants.

Wyssen Skyline Crane

The final treatment phase of our study of the effect of logging methods on water yields and quality has begun. Mr. Wyssen, his yarding crew of young Swiss, and his new W-200, 10-ton crane arrived on the Andrews Experimental Forest in June. By the first of July they had their equipment set up and operating on a test strip 3,300 feet long and 300 feet wide. By the first of September they had yarded about 1-3/4 million board feet of logs from the strip. Only minor modifications of the machinery were necessary on the basis of this test.

This machine, designed for our heavy old-growth timber, consistently yarded per turn 3-5 thousand board feet of logs measuring up to 45 feet in length. Truck-sized loads were yarded both uphill and down although the system is designed and is most efficient in downhill yarding. When the carriage is moved by gravity it develops speeds of 30 feet per second with good control. Control was due, in part, to the ingenious air brake used on this machine.

The Swiss crew used a powersaw winch to pull the heavy cables to the logs not directly under the skyline. In spite of time required for this operation, they were able to yard up to 75 thousand board feet of logs per day in reasonably dense old-growth Douglas-fir timber.

All this was accomplished with almost no disturbance to the ground. Only occasionally, with the heaviest and longest logs, was there any dragging--and this was only a few bounces as the logs hung from the skyline. Lift given by the skyline raises almost the entire log off the ground as it is yarded into the skyline from the edge of the strips. The undisturbed condition is in sharp contrast to the network of skidroads resulting from conventional high-lead yarding.

Under conditions on the test strip, which admittedly were very favorable, the W-200 appeared not only to bring in the logs with a minimum of disturbance, but seemed to be an economic operation as well. We'll know more about this later.

Now the system has moved to experimental watershed 1 where we have been studying streamflow since 1952. Here, because of cross ridges and irregular topography, Wyssen will encounter more problems, and a stiffer test. About a year from now we hope to have some definite information about what happens when almost 13 million board feet of heavy timber are removed from a 240-acre watershed. That is, we will if the loggers don't knock down our gaging station. To date, we have had several near misses during felling, but fortunately the house and A-35 recorder are both sturdily constructed.

High-lead Logging

Starting concurrently with yarding on watershed 1, our operator on watershed 3 will begin logging by the high-lead system, three clearcuts making up about 25 percent of the area on watershed 3. For the past 3 years we have been studying the effect of roads necessary to log by this system. Preliminary results have been reported previously.

Bedload Measurements

Since we have been measuring bedload by the grid system of leveling the bottoms of our settling ponds, we have wondered about the accuracy, but never seemed to have the time to repeat the measurements. This past year, because of the slide in our watershed 3, reported in the last semiannual report, we measured one basin, both in the spring and again in the fall, with no storm or appreciable sediment movement in between. The results were encouraging as the two measurements tallied closely. Bedload from the two undisturbed watersheds during the past year was below average for the past 5 years, varying from .61 to 1.23 cubic feet per acre of drainage.

On the Coyote Creek watersheds in South Umpqua Experimental Forest, we measured the accumulation in the stilling ponds the hard way--shovel and wheelbarrow. Although we thought we had unusually high bedload movement during the last Thanksgiving storm, the total measured for the year was not much greater than the average from the H. J. Andrews Experimental Forest. Watershed 1, a 180-acre drainage, averaged 2.17 cu. ft. per acre; watershed 2, a 160-acre drainage, averaged 0.70 cu. ft. per acre.

--Jack Rothacher

Soil-Vegetation Studies

During the past summer, work was begun on two new studies in the experimental watersheds in the H. J. Andrews Experimental Forest. Both studies are related to the logging that got underway late this summer in two of the watersheds.

First is a study of soil disturbance resulting from three methods of logging--skyline, high-lead, and tractor. We plan to obtain a quantitative estimate of severity of disturbance by means of bulk density determinations for the surface 1-1/2 inches of soil. So far, of course, we only have figures for the "before logging" samples. Because sampling was confined to soils having closely similar surface soil characteristics, variation among samples was minimized. Even so, the standard deviation approached $\pm$ 0.1 gm. Bulk density means were found to be unually low, even for surface soils, ranging from 0.66 to 0.71 gms./cc. This is probably due to the large quantities of volcanic ash present.

The second study is an investigation of plant succession following logging on experimental watersheds 1 and 3. The study involves the estimation of plant cover in milacre plots arranged along transects at 100-foot intervals. This summer we completed the prelogging sampling of 197 plots, which are permanently referenced so they may be relocated following timber harvesting operations. Plans call for rereading the plots at yearly intervals for at least 5 years after logging. Under undisturbed conditions we find we can identify six distinct understory communities which occur under old-growth Douglas-fir stands. They are named for the dominant species as follows: (1) hazel-salal, (2) rhododendron-salal, (3) vine maple-salal, (4) vine maple-Oregon grape, (5) gold-thread, and (6) sword fern. It will be interesting to see whether successional patterns will differ appreciably within these various communities following logging and slash burning. We also expect to find the postlogging vegetation data useful in the interpretation of streamflow characteristics.

This summer, National Forest Administration crews mapped the soils on the entire Andrews Experimental Forest. As we were beginning to suspect, the area occupied by our experimental watersheds has one of the most complex soil patterns on the forest.

--C. T. Dyrness

Erosion from Roads

Along with many others, we have been trying to find a method of estimating total yield of suspended sediment. In the experimental watersheds at the H. J. Andrews Experimental Forest, early autumn samples show that streams carry disproportionately higher sediment concentration during fall storms than flows of corresponding discharge during midwinter storms. Furthermore, sediment concentration is highly variable during the fall, both from storm to storm and from year to year. Attempts at multiple regression analysis have been fruitless.

In late autumn, sediment concentration becomes less variable and diminishes to values predictable by the stage of the stream. This relationship remains true for the midwinter period, and we think it begins each year when the solum is fully recharged by fall rains.

Dry ravel from stream-cut banks during the dry season undoubtedly is a source of some of the early season sediment. However, streams carry sediment concentrations in excess of midwinter predicted values even after they have been well flushed by preceding storms. A large part of this sediment may originate within the solum and is carried with intra-soil runoff. Everyone who has poured water through a dry soil column has observed a surge of sediment with the first water to percolate from the column. After complete saturation, additional increments of water come through the column relatively "clean." The solum, during this early fall period, is recharged in stages by a series of storms. During inter-storm periods, wetting fronts move through the profile and considerable evapotranspiration occurs. Water from the next storm meets soil at some intermediate stage of recharge. We would be glad to accept any views and/or evidence to support or discredit this theory.

A partial estimate of suspended sediment yield was made for a 250-acre watershed in which 1.65 miles of logging road were constructed during the summer of 1959 for 2 years previous to construction and 3 years after road construction. Yield was estimated for a 159-day winter period beginning on November 23, and ending April 30 of the next year--this being the period of predictable relationship.

A linear equation fits samples taken during this winter period. By covariance, it was determined that samples taken on a rapidly rising stage carry sediment concentrations significantly greater than would be predicted from the common regressions. Periodic sediment yield was the product of sediment concentration and weighted mean discharge for 3 c.f.s. discharge classes. Prediction equations and corresponding correlation coefficients for conditions before and after road construction are:

Watershed Condition	Equation	r
Before construction	Log Y = -.075+1.673x	.942
After construction:		
(Rapidly rising stage)	Log Y = .575+1.609x	.941
(Falling stage & moderate rise)	Log Y = -.117+2.059x	.902

in which:

Log Y - is the log suspended sediment concentration + 1.
x - is stage in feet.

Rapidly rising stage is defined as a rise of .07 feet or more for the second and third hour preceding sampling. Samples taken on a moderate rise were not different from samples taken on a falling stage.

The following table summarizes the suspended sediment yield for the midwinter for 5 years. Note that sediment yield variation from the watersheds without roads is large--as great as the variation in post-construction yields. Yields are proportional to runoff, but we suspect they are weighted heavily by the time the streams are at high stage. Sediment yields, which more than doubled following road construction, represent a considerably lower estimate than were cited in an earlier issue of the semiannual report. These yields are small compared to the yields in thousands of tons per square mile reported for watersheds in the southwestern United States.

Season[1/]	Total runoff for season	Suspended sediment	
		No roads	With roads
	(Million cu. ft.)	(Tons)	(Tons)
Before road const.			
1957-58	47.2	29.80	--
1958-59	27.5	2.97	--
After road const.			
1959-60	24.3	2.83	4.39
1960-61	42.1	12.30	28.00
1961-62	34.5	8.26	19.50

[1/] November 23 to April 30.

Water Chemistry

We have now 1 year of data from our water chemistry study, designed to detect changes in the chemical composition of runoff water following logging and slash burning in two watersheds. One problem was discovered by accident when paired samples were rerun because they did not compare well in the first analysis. We were surprised to find that the reruns paired no better, in most cases, and that the mean TDS value was always lower than the mean of the first run. After kicking the problem around for some time, we think that micro-organisms in our samples are tying up chemicals from the sample in a nearly invisible scum at the waterline. Our solution is to refrigerate samples, held for analysis more than a few days, and minimize the time from sample collection to analyzing. Toxic chemicals could be used as well to prohibit the growth of micro-organisms.

The study was recently expanded to include changes in the level of individual elements. The expansion was made possible by a cooperative project with the Public Health Service whereby they will do the analytical work. We will follow the same basic sampling scheme outlined in the study plan but will supplement it with a series of partial and complete analyses of water samples.

Soil Moisture Study

The pretreatment period of our soil moisture study, designed to show changes in water use on Douglas-fir clearcuts, is now completed with 3 years data. We are sensing soil moisture changes with 10 stacks of Coleman soil moisture units, field-calibrated to the upper 4 feet of soil.

We have been impressed by two major deficiencies of the Coleman fiberglass unit: (1) its lack of sensitivity at moisture levels near field capacity and (2) shifting calibration curves. The first deficiency is well documented in the literature and was no surprise. The second deficiency is especially troublesome since it means recalibration of each stack of Coleman units per year. The shift in calibration has been consistently toward a greater resistance at the same soil moisture level.

--R. L. Fredriksen

Bull Run Experimental Watershed Study

The experimental watersheds in the Bull Run Reserve, which we have calibrated since 1956, will be ready for treatment in 1963. Three east-west trending watersheds are available: numbers 1, 2, and 3, with watershed 3 serving as the control. The proposed experiment will answer four questions:

Is watershed hydrology affected by

1. the presence of logging roads?
2. the orientation of logging strips?
3. the climatic exposure of a cutting area?
4. harvest cuttings in an adjacent watershed?

To answer these questions, watersheds 1 and 2 will each be subdivided by their streams into two subwatersheds: A (north-facing) and B (south-facing). Proposed treatments will then be as follows:

Phase 1 - Build access roads in subwatersheds 1A and 1B. - 1963

Phase 2 - Harvest subwatershed 2A in east-west strips. - 1966

Phase 3 - Harvest subwatershed 1A in north-south strips. - 1967

Phase 4 - Harvest subwatershed 1B in east-west strips. - 1969

Phase 5 - Build access road into subwatershed 2B. - 1971

Phase 6 - Harvest subwatershed 2B in north-south strips. - 1973

--Nedavia Bethlahmy

WENATCHEE, WASHINGTON

The last 6 months have been spent largely in preparing for the future. This was started with 6 weeks of training at the Oak Ridge Institute of Nuclear Studies. The following are briefly some of the impressions and observations made during the 6-week course.

The ORINS courses are very well organized (considering the wide scope of technical people served) in terms of subject matter, and these subjects are well presented by the competent and personable senior and technical staff. In essence, the three 2-week courses consisted of: course A, basic nuclear physic and electronic systems for detection of

radioactive decay; course B, radiochemical research technique and application to practical isotope problems; and course D, advanced or research radiochemical techniques.

In more detail, course A provides the fundamentals of radioactive decay processes with lectures on origin and sources of radioactive decaying materials, types and rates of decay processes, and interaction of radiation with matter. The laboratory sessions, which consist of about 50 percent of school time, are concurrently presenting introduction and use of various counting and detection systems. Interspersed in this schedule are several lectures on radiation safety. Course A can definitely be termed a "rat race." In my case, I had to learn the language as well as the material. Even a person more familiar with the field is kept quite busy with homework, etc.

Course B largely involves nuclear chemistry and handling of isotopes in the lab. This instruction maintains continued use of various counting and detection systems in connection with the particular experiment. Again, radiation safety is given some attention, and new subjects such as autoradiography and AEC licensing are covered. The course has a somewhat slower pace than A, which gives time to pull the courses together and think a little more about what you are doing and why.

Course D is quite a marked contrast to A. The pace drops to a near normal work tempo (a 40- to 50-hour week approximately). The material is more technical in nature and more specific in scope of application. I found most of the material to be very interesting with many potential areas of application to our fields of soils and watershed research. The slower pace allowed time for discussions with the staff relating to our special problems with use of isotopes. This included discussions of lab design, lab safety, types of counting equipment, and problems in soil chemistry and chemistry in general. I found these discussions very informative and useful.

In course D we also had time for general use of the ORINS library, several visits to the Oak Ridge National Laboratory, and one visit to the University of Tennessee Agricultural Experiment Station. These visits were quite valuable in this stage of the training, as I was able not only to see the types of research in progress and talk to the persons in charge, but also question these people as to their ideas on some of the projects we might undertake.

In summary, I can conclude the courses were excellent and well worth the time and expense involved. I would highly recommend the session to any of the watershed staff, providing there is some chance of obtaining counting equipment.

The other phase of preparing for the future is related to the research program of the Forest Hydrology Laboratory. We are in the process of preparing a soils problem analysis. Previously, we have been concerned only with eastern Washington; however, the new lab program has been assigned watershed research responsibility for both eastern Washington and eastern Oregon. Development of the problem analysis has required travel to parts of eastern Oregon for on-the-spot views of watershed problems.

--Dave Wooldridge

Soil Moisture

The entire field season has been spent installing neutron probe access tubes. We now have 137 tubes installed in a variety of soil conditions. Stony soil conditions have forced us to install the access tubes in oversize holes. A 2-1/2-inch auger has proven satisfactory for most of the holes, but one set required large excavations, with the tube placed in a corner. Because of these oversize holes and the attendant need for an equilibration period, our data collection program has been delayed. The one set of readings we have taken indicates a higher degree of uniformity at a given location than I really expected. These readings were taken at the time of maximum soil moisture depletion; however, wetting and drying periods will undoubtedly display considerably more variation.

I would like to solicit comments on the conversion of counts per minute (or count ratio) to percent moisture. It is possible, of course, to express the P_v to the nearest decimal percent (0.1 percent). My feeling is that the inherent precision of the method plus the rather large random variation found in most soils does not justify such expression. Do we really have such accuracy, or are we deluding ourselves? I have decided to express P_v to the nearest whole percent and would be interested in comments from other workers.

Cold Weather Weir Operation

I hope that the icing problem at our Fox Creek weir has finally been licked. This summer we installed a shed roof and front wall over the entire weir pond. Last winter we tried one of the PSW Station's hoods over the notch; it froze in place, 6 inches of ice formed over the entire pond, and the water flowed out through an ice "pipe" to the streambed below. This creates a very interesting hydrograph. The ice first causes the water level to rise to an abnormal level, but as soon as the ice "pipe" filled, siphoning action started and the water level dropped below normal. When the siphon lost suction, the water level quickly built back

up and the cycle started all over again. The period of such a cycle was about 2 minutes, and it has continued for as long as 2 days before the pipe broke. The trace looks more like an oscillograph trace of a radio signal than it does a hydrograph!

A propane pilot light with a very small (3/4-inch) flame has kept the stilling well ice-free all winter. Such a flame will burn for 8 to 10 weeks on 20 pounds of gas. I would be glad to send details of the installation to anybody interested.

--Gene Herring

Microclimate Studies

Development of a suitable basis for the study of the microclimate continues along many lines. One of these, specific equipment design of pyranometers, was reported in the previous semiannual report. The same procedure (electrodeposition) for integration has been broadened to include an integrating light and temperature device which will be presented in a publication soon.

An instrumental network for solar input covering one of the major drainages through this area has been designed and submitted. Due to availability of a number of recorders and power outlets (state and private), continuous recording of this environmental parameter is possible.

In this regard, I would like to hear from anyone having data of synchronous measurement of solar and net radiation and cloud amounts over any cover type, preferably in the form of day or 24-hour totals.

Equipment of all types for both field and lab is required for microclimatic studies. Much of it is single usage and expensive. Through a workable relationship with the GSA Excess Property Division, some of this equipment has been acquired.

Certainly, one takes risks regarding condition of this material; some of it is in very bad condition and not reported as such. The best source I have found so far is a deactivating Titan site. This equipment is excellent in both initial quality and present condition. Unfortunately, the U.S. Forest Service doesn't rate very high on a priority list for this equipment. There is some doubt at present as to how much of what I've requested I'll actually get.

The preparation of a problem analysis in conjunction with Herring and Wooldridge to serve as a guide to research for the new lab is also in progress. The opportunity to see various problems and problem areas in the field and discussions with field personnel have been valuable. The final assessment and assignment of priorities have not been completed.

One problem of especial interest, however, is the measurement of evapotranspiration and assessment of the net radiative budget. For forested stands this is a difficult measurement. A study plan for this, utilizing a modified sonic anemometer-thermometer has been prepared. It is lengthy, involved, and expensive, and will take a considerable amount of research time. Choice of a field site and preliminary installation of some check soil moisture access tubes have been completed. These soil moisture plots will be used in conjunction with Herring's lodgepole studies. The short-time resolution of the neutron probe, however, may not be suitable for the check on evapotranspiration desired for my study. This may require further consideration.

--Bill Fowler

Tree Root-Water Absorption Study (Corvallis)

Our first objective is to determine the amounts of water absorbed through suberized and unsuberized root surfaces. Later, the study will be expanded to consider the ways in which root factors (anatomy, morphology) and soil factors (moisture, temperature, aeration) affect water absorption by tree roots.

Some results have already been obtained for suberized red alder roots obtained by digging in the field. Water movement through the roots is measured in the laboratory by enclosing the roots in a pressure chamber and forcing water through the roots under pressure. Preliminary results obtained with red alder showed that water movement through the suberized root surfaces is very slow (0.00086 ml/hour/cm^2 of root surface). It is interesting to note that the rate of water movement through suberized yellow poplar roots in North Carolina, measured in the same way, was much greater (0.0038 ml/hour/cm^2 of root surface). Apparently, the water permeability of roots of different tree species varies considerably and may be an important factor affecting the amount of water absorbed and transpired by different species.

Currently, arrangements are being made to pot up several hundred hardwood and coniferous tree seedlings in the greenhouse for use in future experiments. It is hoped that they will provide a more dependable and uniform supply of root material at desired stages of development than can be obtained from the field.

--William Lopushinsky

SEMIANNUAL REPORT

Pacific Southwest Forest and Range Experiment Station

April through September 1962

WATER SOURCE HYDROLOGY

Northern California Regional Analyses

Progress on the three regional studies (Flood Peak Discharge, 2-2; Suspended Sediment Yield, 1-18; and Water yield, 1-10) has largely been confined to collecting and processing data on land use and watershed geometry for approximately 400 study watersheds. In many instances, these three companion studies need identical information so a common data pool has been formed. Rapid methods of data collection and processing have been developed which make advantageous use of the University of California's IBM 1620 and IBM 7090 digital computers. Two Fortran programs for the IBM 1620 are discussed below as they may be of general interest.

Area-Elevation Data

A Fortran computer program is available which handles any relative area measurement (either dot count or planimetered) for seven to fourteen elevation classes. The output consists of mean basin elevation, elevation class mean, percent area within each elevation class, and an area-elevation table. The latter lists elevations by 0.1 linear increments of the original classes, and tabulates the area (square miles) and the cumulative percent area below that elevation. A write-up of our techniques and of the computer program is available from the Station.

Stream Length Mean and Coefficient of Variation

One of our watershed shape parameters is the coefficient of variation for stream lengths within the watershed. A general Fortran program was written to handle this data. The output lists the mean, standard deviation, and coefficient of variation for a set of observations. This program and a discussion of the parameter is in the process of being written up.

Fire History Data

A compilation is nearly complete which will list the fire histories of all 400 study watersheds for the period 1940 - 1959. The data includes all fires that burned more than 100 acres (about 90-95% of the acreage burned each year). A filing system was designed to permit considerable flexibility in rapidly determining fire histories for additional areas or watersheds with a minimum of additional effort. Any fire occurring outside of the study watersheds was filed under the appropriate

California Department of Water Resources hydrographic subregion. The watershed listings are compiled on the IBM 7090 computer.

Land Use Data

Our other land use data are based upon rapid aerial photo interpretation sampling techniques. Information is being collected on the percent of the watershed area in the following categories: urban, cropland, roads, stream channel, water surface, grass, barren, brush, forest, and logged area. In addition, slope and aspect estimates are made for each vegetative cover type and for barren areas. Cover densities are estimated for brushlands and forest. Several measures of logging effects are collected in this inventory including road location, and exposure of bare ground within the logged area.

So far, we have been using 1:15,000 and 1:20,000 photographs and have finished most of the north coastal drainages. At these scales, the number of photographs to be secured and handled slows down the interpretative work.

As a result, we have been exploring the possibilities of using high altitude (1:60,000 - 1:85,000) coverage for the rest of the state. We recently obtained 120 negatives of U-2 flights over the Sierra Nevada from Lake Tahoe south to the Kern Plateau. We are having these printed so that we can evaluate the possibilities of using the U-2 photography for making land use inventories of watersheds along the south coast and in the Sierra.

Kenneth L. Bowden, James R. Wallis,
and Lucille G. Richards

Soil Erodibility

Our Soil Erodibility study has recently been extended to the Teakettle Experimental Forest (6500 to 8000 feet elevation). The main objective is to find if any differences in erodibility exist between these soils and those wildland soils previously measured (1000 to 4000 feet elevation). Soil sampling procedures were consistent with previous studies and it is hoped that the analyses will show more fully the role of vegetation in relation to soil aggregation.

We have a 1620 computer program for making the erodibility computations. The input data includes the percent and sieved weights of stones in 3 size classes >25.4, 25.4-5, 5-2 mm, hydrometer readings basic to measuring the soil textural classes < 2 mm and suspension analyses. The output results are given in terms of the erodibility indices for each sample based on Middleton's Dispersion Ratio and Anderson's Surface -

Aggregation Ratio. As approximately 80 separate arithmetic operations are required for each sample, we estimate that 1 man-day of hand calculation per 10-12 samples analyzed can be saved by this program. A write-up is available upon request.

Donald W. Willen
James R. Wallis

SNOW ZONE HYDROLOGY

Summer Evapotranspiration Trends as Related to Time Following Logging

The quantity of summer soil moisture loss from logged forest openings was related to the length of time since the creation of the opening. The study was located in the sub-alpine forest zone of the Sierra Nevada west-side, near the Central Sierra Snow Laboratory, California, within the elevational range of 6,000 to 7,000 feet. Soil moisture depletion was measured in forest openings which were created in 1959, 1955, 1950, 1948, and in the forest surrounding these openings. At the period of maximum soil moisture depletion, openings one year of age were found to have 6.9 inches more soil moisture per 4-foot soil than did the surrounding forest, which is an expression of the quantity of moisture saved as a result of the logging operation. In openings five years of age, the saving has decreased to 2.9 inches, after ten years to 1.2 inches, and after twelve years to 0.7 inches. A projection of the regression indicates the moisture saving at maximum depletion will reach zero 16 years after cutting. Soil moisture depletion is traced through two summer depletion seasons and into the fall moisture recharge period. The effect of soil field capacity, soil depth, ground cover, and summer precipitation upon soil moisture depletion trends is also discussed.

Robert R. Ziemer

Use of Gamma and Neutron Sources in Measuring Hydrologic Characteristics of Snow

Commercially available probes with gamma and neutron sources (Nuclear-Chicago, P-20 and P-19 probes) were tested for their ability to measure characteristics of snowpack profiles: density, ice layers, and thermal quality (free water). These characteristics are hydrologically important in predicting the total water supply from snowpacks, the start of snowmelt, the rate of snowmelt, and the detention of water within the snowpack. Tests were also made of the zone of effective neutron moderation

and gamma scatter, the effect of access tube position on the counts, and the effects of proximity to the snow and soil surfaces on neutron and gamma counts.

Usable regressions with neutron (Cn) and gamma (Cg) counts per minute were obtained for snow densities measured gravimetrically with a range of 12 to 60 percent. At depths greater than 12 inches from the snow surface, the relation of density (D, in percent) to neutron counts was: D = 9.2 + 0.0062 Cn. At the 6-inch snow depth, D = 9.2 + 0.0082 Cn. For this probe in aluminum access tube water count was 15,900 CPM.

For gamma counts (in thousands) at depths of 18 inches and greater, $D = 1.5 + 0.39 (Cg - 5) + 0.0213 (Cg - 5)^2$. At 6-inch snow depth, $D = 0.00185 (Cg - 5)$, and at the 12-inch depth, $D = 0.00126 (Cg - 5)$. Count in water for the gamma probe with aluminum access tube was 44,400 CPM. In each of these simple relationships of density to counts, standard error of estimate was about 2.5 percent density. Counts taken at 6-inch intervals above and below each depth may reduce this error.

The volume of snow affecting the neutron and gamma counts was studied by taking counts in cylindrical columns of different radii. The radius of the cylinder of snow at which the probes gave 95 percent of full count varied only slightly with snow density. For snow densities of 44 and 26, respectively, the radii were 11 to 12 inches for the neutron probe and 16 to 18 inches for the gamma probe.

The access tube itself is a part of the instrumentation. In measuring surface snow density, we found it essential to extend the aluminum access tube at least 12 inches above the snow for the gamma probe; an extension of 6 inches, for example, gave 11 to 23 percent lower counts (at depths of 3 and 9 inches below the snow surface) than a 12-inch extension of the access tube.

The gamma probe determined density of the snow within about 8 inches of the soil surface (snow density was 0.47). At closer than 8 inches to the soil surface gamma counts were reduced. The neutron probe determined density to the soil surface.

Ice layers in the snow were detectable by shifts in the counts from the neutron probe. Laboratory tests indicated neutron counts 3 to 12 percent less in ice than in water (for equivalent densities).

Differential responses of counts to water and frozen snow were also indicated in field tests. The ratio of gamma to neutron counts was directly proportional to thermal quality of the snow for two successive days with identical average snow density (56 percent) but with thermal qualities of 82 and 95 percent.

This study is financed by the AEC and is part of the California

Cooperative Snow Management Research Program being conducted by the Pacific Southwest Forest and Range Experiment Station of the Forest Service, USDA, Berkeley, California, with the cooperation of the State Department of Water Resources. The field tests were conducted at the Central Sierra Snow Laboratory near Donner Summit, California. The laboratory tests were conducted at Duke University. The collaboration of Myron B. Hawkins, L. G. Richards, and C. W. Mansfield in the studies is gratefully acknowledged.

Henry W. Anderson, Philip M. McDonald, and Lloyd W. Gay

SAN DIMAS EXPERIMENTAL FOREST

Grass Interception

This spring we completed a cooperative study of rainfall interception by grass. The experimental design was altered slightly from that reported in the April through September 1960 Semiannual Report. The past two field seasons were spent in obtaining intensive measurements of interception losses on one species of grass; soft chess. This should make it easier to isolate the effects on interception of growth stage of grass, amount of precipitation, and other measured variables. The number of sample sites was increased to 40. Other methods and procedures remained the same.

During the past three years only 25 storms totaling 9.80 inches were sampled for interception measurements. This was due in part to subnormal rainfall (precipitation in two of the three years was 45 percent of normal) and in part to difficulties in developing a stand of grass suitable for interception measurements from early winter storms.

Preliminary results from field data collected show definite relationships between storm size, grass quantity, and interception loss (fig. 1). Interception loss from mature chaparral 1/ is included for a comparison with the grass interception curves. In interpreting the graph it must be realized that annual grasses start growth with the first rains of 0.5 to 1.0 inch, usually in October 2/. However, growth is usually limited by low temperatures or insufficient precipitation during the fall and winter. Plants grow rapidly from February or March until the rains diminish in April or May. Thus a good portion of the annual precipitation falls

1/ Hamilton, E. L. and P. B. Rowe. Rainfall interception by chaparral in California. California Forest and Range Experiment Station and State of California Division of Forestry. 1949.

2/ Bentley, J. R. and M. W. Talbot. Efficient use of annual plants on cattle ranges in the California foothills. USDA Circular No. 870. 1951.

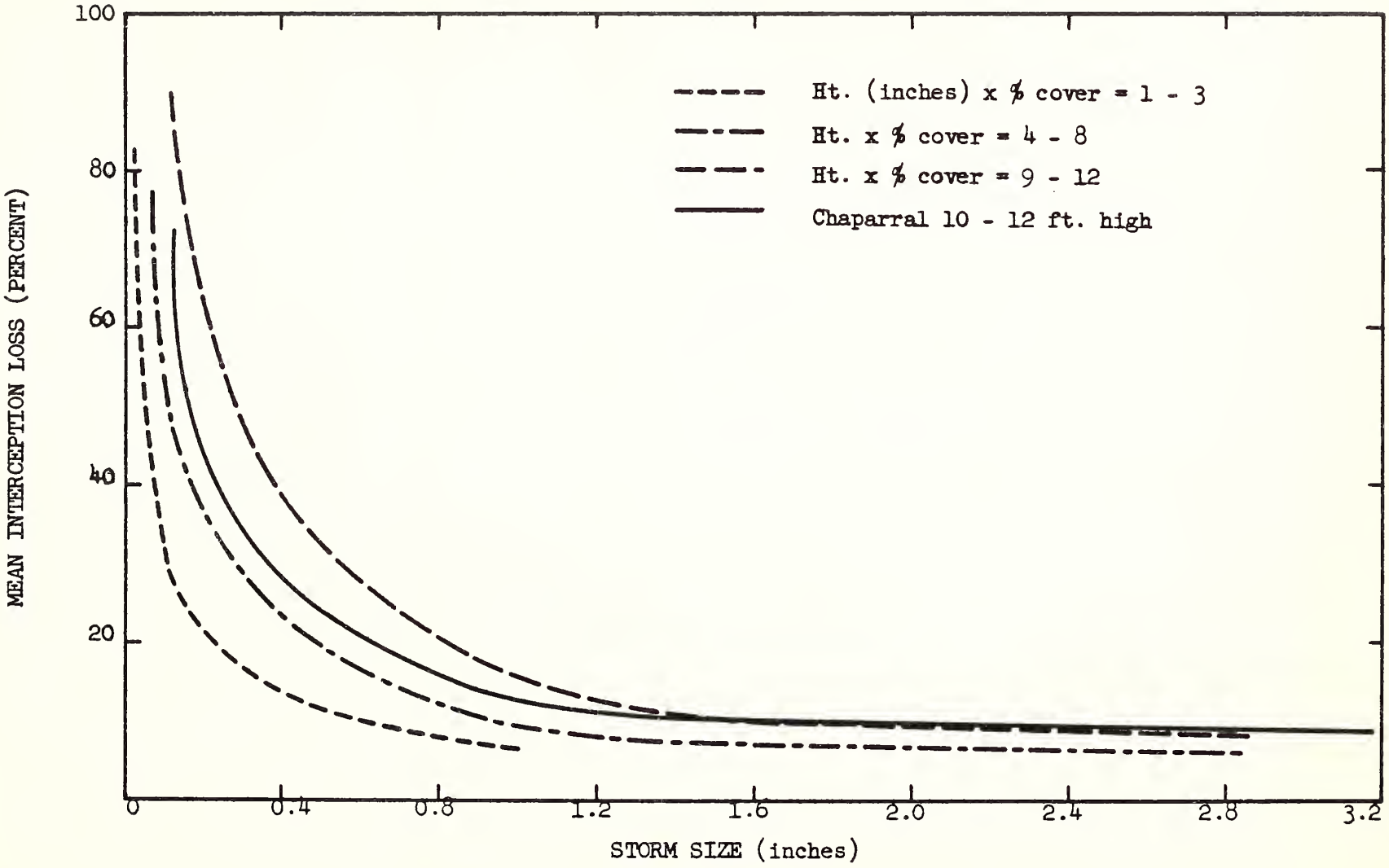


FIGURE 1. RELATION OF INTERCEPTION LOSS TO GRASS QUANTITY, MATURE CHAPARRAL, AND STORM SIZE

when the grass is in its lower stages of development.

In their work with chaparral, Hamilton and Rowe found that 11.1 percent of the annual precipitation was lost through interception at San Dimas. This included storms from 0.10 to 11.50 inches in size. We did not measure any storms over 2.72 inches for grass. However, a rough extension of the curves in figure 1 would result in an annual interception loss from grass of approximately 6 1/2 percent using the chaparral storm data. If we include only those storms up to 3.35 inches, interception loss from chaparral and grass respectively would be 15.7 and 9.3 percent.

The data is presently being processed through a step-wise regression analysis program. Variables being tested include grass quantity (surface area index and height x percent cover), storm size, length of storm, duration of breaks in storm, rainfall intensity (average for storm, last 30 minutes, high 5 minute intensity during last 30 minutes) evaporation during storm, evaporation since last storm, wind speed (average for storm, last ten minutes), and combinations and transformations of them. We plan to develop prediction equations for rainfall and interception loss relations for an annual grass cover and to examine thoroughly the interception process.

E. S. Corbett

Work was continued on the 4 main studies underway and on further analysis of data from the soil trafficability study completed in 1961. No new studies were started although availability of rainfall and streamflow data for the Waiakamoi watershed on Maui was investigated and some data obtained.

Soil Erodibility Study

The soil erodibility study plan states that dispersion ratios will be determined and used as an index to erodibility of wildland soils. Early laboratory work shows that measuring dispersion ratios for tropical soils using the hydrometer is tedious because complete oxidation of organic matter with hydrogen peroxide is slow. Following a staff meeting at Berkeley, other measures of erodibility such as aggregate analysis using wet sieving technique, rain splash, and hydraulic tests using flume devices are being considered. One or more of these methods will be used along with the dispersion ratio to determine erodibility indexes.

Results from line transect samplings at Pohakea Pass, Oahu show that soil under eucalypts are less erodible than others. Soil under eucalypts was fine-grained but the others were gravelly.

Transect results are as follows:

Pohakea Pass, Oahu

Site No.	Elev.	Parent Material	Vegetation	Slope	Suspension Percent	Dispersion ratio
1	1050'	basalt	grass and shrub	30%SE	19.0	45.7
2	1150'	basalt	eucalypts	41%N	3.1	4.4
3	1150'	basalt	silk oak	65%S	7.0	25.1
4	1880'	basalt	silk oak	45%N	9.0	20.8

	Surface Aggregation ratio	Rainfall
1	24.8	35"
2	6.5	35"
3	15.6	35"
4	16.7	45"

Kaukonahua Runoff Study

Several analyses have been made of the data collected by the Division of Forestry in the Kaukonahua Runoff Study. The consistency of rainfall data was tested. Monthly and yearly flows were calculated for each gulch--Tree Gulch and Fern Gulch.

For each storm over a wide range in size and time of storms, the following variables were selected: total storm rainfall; 7-day antecedent rainfall; 30-day antecent rainfall; 15-minute maximum intensity rainfall; and cross products of these variables. The variables will be related to storm runoff and peak discharges by multiple regression.

Evapotranspiration so Measured by Soil Moisture and Rainfall

We started measurements of soil moisture and weather factors at 6 new sites located in drier part of Oahu than the sites established earlier. Early results from these new sites show:

Cover type	Total water content to 10.5ft. depth(inches)		Decrease in total water content for interval (inches)	Rainfall for interval (inches)
	mid-April	mid-Sept.		
paperbark	46.4	38.3	8.1	7.5
silk oak(1)	39.8	38.5	1.3	7.2
silk oak(2)	48.6	40.2	8.4	10.0
eucalyptus	43.7	37.2	6.5	10.0
	mid-July	mid-Sept		
grass	46.7	46.4	0.3	2.1
brush	48.9	44.3	4.6	2.6

The sum of soil-water content and rainfall for the interval considered can be called the water loss caused by vegetation through evapotranspiration and interception. Silk-oak (1) has the smallest decrease in soil moisture content which may be due to lower initial soil moisture content. Access tubes were not established in the grass and brush sites until late June or early July.

The Minuteman power auger was tried, at several locations on Oahu to prepare holes for the access tubes for soil moisture probe. The trials

showed the auger unsuited to our heavy soils. The auger would not carry the soil out of the hole and is, in our opinion, too heavy and awkward for efficient and safe use.

Further Analysis of Soil Trafficability Study Data

A first draft of a manuscript titled "Soil Moisture Trends at Six Sites on Oahu, Hawaii" was completed. Graphical analysis was used primarily to study soil moisture in the upper 12 inches of soil in relation to rainfall, time, and vegetation cover.

Selection of Experimental Watersheds

Through study of maps, aerial photos, and streamflow records and ground reconaissance, 7 gaged watersheds--2 on Molokai, 2 on Oahu, and 3 on Maui-- were selected as tentative experimental watersheds. Our next steps in this project are to obtain approval of landowners for use of the watersheds for experimental purposes and more detailed surveys of suitability for experiments.

Waiakamoi Runoff Study

The U. S. Geological Survey and the State Division of Forestry established a stream gaging station and a network of raingages in 1949 on upper Waiakamoi watershed on Maui. We have the streamflow and rainfall data. After preliminary review of the project and the data we may propose a study for analysis of the rainfall-streamflow relations on the watershed.

Paul Duffy and Teruo Yamamoto

SEMIANNUAL REPORT

Division of Watershed Management Research
Rocky Mountain Forest and Range Experiment Station

April - September 1962

GENERAL

Summer 1962 was one of new experiences for many of us at the RM. Orr reports a wet season in the Black Hills, while Glendening coped with a record summer drought in Arizona. Hoover was in Alberta to advise the Eastern Rockies Forest Conservation Board on watershed management practices and research opportunities. He promises to tell more about that later.

Watershed management on the National Forests gained when Byron Beattie persuaded Ed Dortignac to come to the W.O. as staff hydrologist. We hope Dort will still be able to help with problems in our area but we realize we can't help but lose while other areas gain from his skill and experience. Earl Aldon has moved to Albuquerque to lead the Watershed Restoration project headquartered there. J. R. Thompson is the new assistant in the Watershed Management Research Division.

New people and their assignments are:

Arthur Judson	-	Alpine-Avalanche
James Bergen	-	Timber-Snow
Charles Leaf	-	" "
Stuart Parks	-	" "
Ernest Frank	-	Revegetation
David Sturgis	-	Water Yield - Laramie
Arnett Mace	-	Pine-Fir - Tempe

Evaluating gully control measures

In 1961 a study started on the Alkali Creek Watershed, White River National Forest, to install and to evaluate the effectiveness of certain gully control measures. One purpose was to test ideas developed in our Station Paper No. 55, "A Study of Early Gully-Control Structures in the Colorado Front Range."

The project is cooperative with Region 2. The study area lies on the western slope of the Rocky Mountains on soils derived from Wasatch shales and sandstones. Within a fenced area of about 800 acres, 18 gullies have been surveyed, their physical characteristics determined, and certain critical locations referenced on the ground. The gullies carry ephemeral flow only. Rain gages were distributed on the area to detect appreciable differences in precipitation between subwatersheds during a given flow-producing storm. Simple flood stage recorders will be installed in the gullies and spillways of check dams to obtain indications of the flow. Road culverts will be utilized where available. Soil analyses are being made. Vegetation on the subwatersheds will be sampled by simple procedures. Records on work-time, material and cost of treatments are kept.

Control measures are designed to be effective and economic under the given watershed conditions. So far, one gully has been treated by check dams, and one has been replaced by a waterway.

Two types of check dams will be applied. One type consists of simple materials such as loose rocks, metal fenceposts, and wire mesh. In contrast to most of the older works, the hydraulic requirements are incorporated in the design of the simple dams. Different structural designs will be used.

The other type of check dam is planned to incorporate modern construction elements and materials (suspended shale in prestressed concrete). This construction type will result in 33 percent saving by weight over conventional concrete. It will also simplify design and installation of check dams since part of the structure will be prefabricated.

Some gullies will be replaced by grass-lined waterways. These waterways will be located away from the fill areas. The gullies will be filled with the excavation material. By installation of waterways, it is hoped to improve the regimen of flow with respect to erosion. Widening of cross-section, decrease of channel gradient, and increase of vegetation cover will result in an increase of wetted perimeter, increase of roughness of flow, and decrease of flow velocity.

It is expected that success or failure of waterway treatments depends to a great extent on the density of the new vegetative cover and its efficiency in withstanding the impact of the flow. Ernest C. Frank, working with us since the beginning of this summer and concerned with the use of vegetation for erosion control, is planning the revegetation for the waterways.

We hope to receive answers to the questions that follow:

1. What is the final sediment gradient above check dams installed on soils derived from the Wasatch formation? (Answer will also yield requirements for spacing check dams.)

2. How effective are different types of structures?

3. How effective is a given gully-control system?

4. What is the cost of different types of gully treatments?

5. How feasible is the use of equipment in structural gully control as applied?

Burchard H. Heede

Revegetation

Revegetating critical sites with the aim of controlling erosion requires that two basic questions about the plant material be answered. The first is, "What will grow?"; and the second is, "So what?" A considerable amount of work has been done concerning the adaptability of various species in the Rocky Mountain region, but aside from the experience gained from cursory observations little knowledge is available of the soil stabilizing potential of individual species.

In an experiment to both expand the list of adaptable species and evaluate their erosion control potential, F. Dean Freeland established a plot on the granite derived soils of the Colorado Front Range near Fort Collins during May and June of 1961. The plot contains 23 tree- and shrub- and 26 grass- and forb-species in a randomized block design. In addition to measuring mortality, certain "growth characteristics" of the plants were to be measured. For example, on the tree and shrub species measurement of crown spread, little production, and time of coming into leaf and leaf fall were to be used to indirectly evaluate the erosion control potential of the various species. Evaluation of grass and forb species was to follow the same lines with measurements taken that would characterize the protective cover afforded the soil surface by the aerial portion of the individual plant. In time, the final root habit and its extent for each species was to be examined.

Measurement of plant mortality and "growth characteristics" were made during the summers of 1961 and 1962. Table 1 lists the species tested and gives the percent mortality for the tree and shrub species and a subjective establishment rating for the grass and forb species based on the 1961 and 1962 data. Litter production was not measured at the close of the 1961 growing season; and, at the time of this writing, leaf fall has not been completed.

The 1961 growing season was extremely favorable, moisture-wise, for the establishment of any species with the result that overall mortality on the plot was low. The higher mortality among such species as Robinia neomexicana, Prunus tenella, and Caragana arborescens may be attributed to poor original planting stock, which, in these instances, was bare root and was suspected of being affected by mold while being held in cold storage. One species on the plot has considerable eye appeal. This is Sambucus neomexicana, which has grown from basal shoots to heights of seven feet and diameters of six feet. Further information concerning the natural habitat and growth form of this species will be appreciated. I am especially interested in finding out if there seems to be any evidence of the existence of a shorter, denser genetic "variety" of this species as one plant on the plot has these characteristics; but I have not had sufficient time to ascertain the causes of its form.

While the measurement of the "growth characteristics" is one approach to indexing the potential of each species for erosion control there is no substantiated connection between the index and the removal of soil by erosive forces. In the future, this problem will be examined more closely with the aim of determining what characteristics of a species are correlated with soil stabilization. This information may eventually lead to some ability to prescribe certain species for the control of certain types of erosion.

Revegetation studies will be coordinated to an extent with watershed restoration studies utilizing structural measures. An opportunity to participate in such a joint undertaking was presented in conjunction with the proposed construction of several waterways on Burchard Heede's Alkali Creek project. On both north- and south-facing slopes, two species of wheatgrass (Agropyron tricophorum and Agropyron intermedium) will be sown.

Aside from observing the ability of these species to establish on the cut and fill areas of the waterways, one unorthodox procedure will be used in the drilling of seed. In contrast to the standard practice of seeding on the contour, two of the waterways will be seeded with the drill rows following the long axis of the waterways. Drilling along this axis will allow the seed drill to make a few big sweeps instead of many short sweeps in order to complete the seeding operation. Two questions to be answered by these contrasting drilling operations are:

1. Are there any differences in the amount of soil movement between the drilling directions?
2. Are there any differences in the spreading of the grasses out of the drill rows between the two drilling directions?

Table 1

Tree and Shrub			Grass and Forb	
Species	Aug. 1961	Sept. 1962	Species	1962 Establishment rating*
	Percent mortality*			
Robinia neomexicana	60	67	Agropyron cristatum	G
Prunus tenella	37	53	Agropyron desertorum	G
Caragana arborescens	30	27**	Agropyron inerme	VP
Caragana pekinensis	10	13	Agropyron intermedium	E to G
Prunus americana	17	13**	Agropyron smithii	F
Rhus trilobata	13	13	Agropyron trachycaulum	E
Ribes leptanthum	0	13	Agropyron tricophorum	G
Pinus ponderosa	0	10	Astragalus cicer	F
Rubus deliciosus	0	7	Atriplex canascens	VP
Syringa vulgaris	7	7	Avena byzantina var. Fulton	VP**
Caragana brevispina	3	3	Bouteloua curtipundula	VP
Crataegus succlenta	0	3	Brassica rigra	VP**
Eleagnus commutata	3	3	Bromus inermis	VP
Juniperus scopulorum	0	3	Elymus junceus	G to F
Prunus melanocarpa	3	3	Hordeum distichon var. Otis	VP**
Caragana microphylla	0	0	Medicago media var. Ladak	G
Caragana pygmea	0	0	Medicago sativa rhizoma	G
Cotoneaster integerrima	0	0	Melilotus alba	E
Eleagnus angustifolia	0	0	Melilotus alba var. Evergreen	E
Prunus besseyi	0	0	Melilotus alba annus var. Hubam	G
Rosa laxa x R. rubifolia	0	0	Melilotus officinalis	E
Sambucus neomexicana	0	0	Melilotus officinalis var. Madrid	E
Quercus turbinella	0	0	Oryzopsis hymenoides	P to VP
			Oryzopsis miliacea	0
			Sporobolus cryptandrus	P
			Vicia villosa	F to P**

*Based on total of 30 plants per species planted in 6 blocks. Spacing between plants is 3 feet.

**One plant dormant, but not dead

*Symbols: E-excellent; G-good; F-fair; P-poor; VP-very poor; 0-failure

**Annuals, rated in August 1961 as follows:
Avena byzantina var. Fulton - E
Brassic rigra - E
Hordeum distichon var. Otis - G
Vicia villosa - E

Ernest C. Frank

Plant and ground cover in relation to runoff and sediment production

This year will complete our sixth full year of record on Black Mesa watersheds. Although the 1962 data has not yet been analyzed (and this was the big year for repeat vegetation measurements), we felt it might be useful to present the results so far.

The study-watersheds comprise part of the Black Mesa experimental pastures. These lie on the Gunnison National Forest in western Colorado. The watersheds are 91, 169, and 272 acres in size. This portion of Black Mesa is at an elevation of 9,800 feet and is characterized by gently rolling topography and an intermingled cover of grassland, aspen, and Englemann spruce.

The smaller of the three watersheds lies within experimental pasture No. 4 and has been designated Watershed No. 4; the largest watershed is Watershed No. 6 lying within experimental pasture No. 6; and the intermediate sized watershed is within experimental pasture No. 5 and has been designated Watershed No. 5. Watershed No. 4 receives light grazing, No. 6 moderate grazing, and No. 5 has a heavy grazing intensity.

Objectives of the Black Mesa study are: (1) to determine the relation of plant and ground cover to runoff and sediment production on three watersheds having a mixed cover of grassland, aspen, and spruce-fir; (2) to test the derived relationships as a means of predicting certain runoff and sedimentation characteristics on these watersheds.

Figure 1 indicates that the large watershed is the most sensitive to cover changes in terms of water yield, and Watershed No. 5 is the least sensitive. This may be explained after accounting for such factors as physiography of the watershed or the amount of watershed occupied by grassland. Watershed No. 5 has the largest percent of grassland and the lowest drainage density in miles of streams per square mile of area. Watersheds Nos. 4 and 5 have a generally northwest-facing exposure. No. 6 has a southern exposure with a steeper stream gradient than Nos. 4 or 5.

Peak discharge is greatest on the watershed with the greatest grazing intensity, and lowest on the lightly grazed watershed.

Ground cover index shows a strong correlation with both peak suspended sediment (p.p.m.) and peak discharge in cubic feet per second per square mile. Suspended sediment concentrations from the watersheds on Black Mesa have been as high as 6,820 p.p.m., and peak discharge has been as high as 96 cubic feet per second per square mile (table 1).

With the additional ground cover data collected this summer, we will complete the analysis of the Black Mesa data, which will include regression analyses using auxiliary variables such as fall-soil-moisture deficit and physiographic factors.

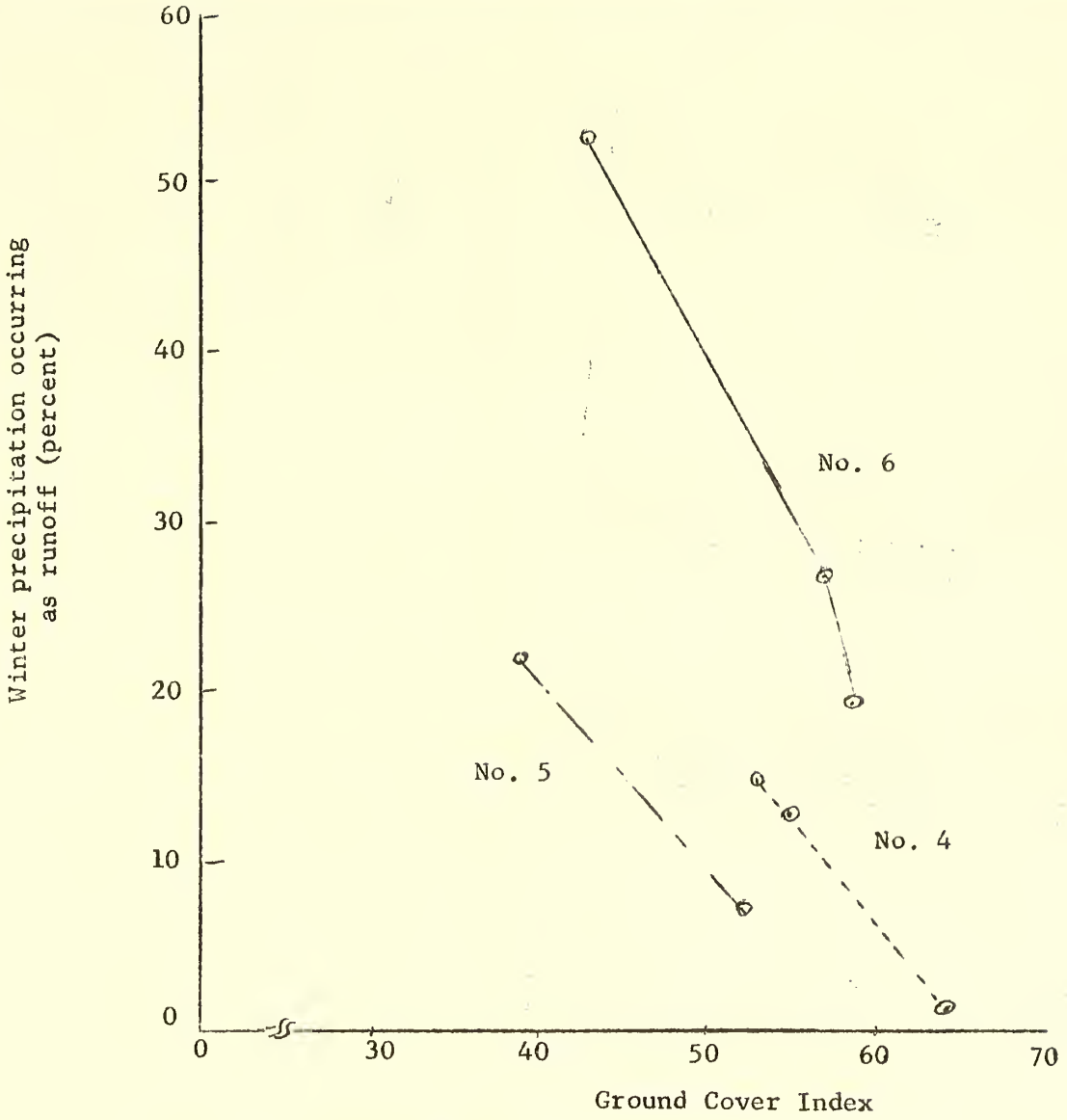


Figure 1.--Black Mesa ground cover streamflow relationship by watershed, 1957-60

Table 1.--Peak discharge and peak suspended sediment concentration from the Black Mesa watersheds, 1957-1961.

Watershed No.	Year	Stream Discharge	Suspended Sediment
		c.s.m.	p.p.m.
	1957	27.2	765
	1958	23.0	633
4	1959	8.3	1950
(91 acres)	1960	17.7	420
	1961	8.1	811
	1957	36.1	6820
	1958	37.0	271
5	1959	24.7	551
(169 acres)	1960	95.9	1844
	1961	52.9	859
	1957	29.0	675
	1958	22.6	621
6	1959	10.1	663
(272 acres)	1960	25.0	1454
	1961	7.1	333

J. Robert Thompson

Floods

Weather in the Black Hills has varied between wide extremes during this report period. The first half of May, usually one of our wettest months, was dry. Then on May 14 the rains began. By the end of the month 9.21 inches had fallen at Rapid City, 6.33 inches above average, record high for the month since measurement started in 1888, and near record for any month of the year. The experimental watersheds in the northern Black Hills received 14.3 inches. Precipitation was near average during the first half of June. Then a period of highly unstable atmospheric conditions and violent storms started on June 14. During the afternoon a tornado formed and touched down in the northern Hills, uprooting and destroying timber. This was followed by heavy rain on June 14 and again on June 15. During the two days 5.47 inches was recorded at the Sturgis Watersheds. On June 15, 2.12 inches fell in one hour, 0.9-inch in 15 minutes. Unconfirmed report of between 10 and 12 inches of rain for the two days was received from one location. Violent storms continued sporadically throughout the rest of June and through July. The three unusually wet months in a row brought calendar year precipitation to 33.8 inches on the Sturgis Watersheds and 25.49 inches at Rapid City. Rapid City received less than 1/2 this much precipitation all of last year. The longtime average annual precipitation at Rapid City is 17.5 inches and the previous record high year was 27.42 inches in 1946. Though August and September have been dry, the 1962 total is almost certain to exceed 1946. The heavy precipitation broke a serious drought condition but it also produced a number of serious floods, particularly in June and July. Most of the May precipitation was of relatively low intensity. Streams flowed high but relatively clear in channel reaches across open aquifers that had not had surface waterflow in years. Conditions were ripe for serious flooding from the high intensity storms that followed in June and July. There was evidence of overland flow even from areas that would be classified in good to excellent hydrologic condition class. However, damage to forest, range, and cultivated land was not dramatic except for some plowed fields. Once flow concentrated in main drainageways the story was different. Channels were cut and gouged, bridges, culverts, and highways were washed out, and in several towns, including Rapid City, streets were washed out, cars and a number of homes washed away, and many basements flooded. Cursory examination led to the conclusion that much of this flooding was due to blocking of bridges and culverts by debris that had been accumulating in and near channels for many years. Had it not been for the debris, much of it man deposited, many channels that flooded would have been able to contain the flow. Partial solutions to the problem of channel capacity under similar storm conditions seem to lie in policing especially vulnerable channel reaches and/or enlarging bridges and culverts. However, it remains to be seen how well this lesson has been learned. This has probably been a 1- in 25- to 50-year storm season.

Moisture use by thinned and unthinned ponderosa pine

For the first time since study was started in 1958, six feet of soil under a dense unthinned stand of 70-75-year pine was fully recharged. In three previous dry years trees on adjacent thinned plots had used more moisture than the unthinned due to carryover moisture year to year on the thinned plots. The year 1957 and the spring of 1958 were relatively wet. Available moisture of 3.25 inches was carried over into 1958-59. The carryover was reduced each year till there was practically none in the fall of 1961. The thinned stand used about 2 inches more than the unthinned in 1958-59. In 1960-61 it used only about 0.2 inch more.

This year, soil on the thinned plots recharged more quickly and has dried out more slowly than on the unthinned plots. It now appears that available moisture will be carried over into 1962-63 on both the thinned and unthinned plots but that the amount will be appreciably greater on the thinned plots.

Estimating storm runoff

I've been through Hawkins' thesis on Missouri Gulch at Manitou and did find it interesting. It contains some parallels to work and statistical analyses of A-B watershed data I was involved in over in Utah.

We used multiple regression and Ezekiels method of successive approximations in trying to relate summer storm runoff and sediment to precipitation factors. The precipitation factors were inches rain per storm, precipitation intensity, and antecedent precipitation. We tried a variety of precipitation intensity factors. The one which worked out best was the total precipitation per storm in excess of .03 inch/5 minutes. Precipitation in each storm was tabulated by 5-minute intervals. 0.03 inch was subtracted from each 5-minute depth and the residuals were totaled. We called this an excess precipitation factor. This factor was more highly correlated with runoff than total depth per storm and in multiple regression eliminated depth/storm as a statistically significant variable. We checked this out for the Deadwood plots (1961 data) and found that weekly runoff was not significantly correlated with inches total weekly precipitation, but was highly correlated with the 0.03 inch excess precipitation factor (correlation coefficients as high as .937).

Watersheds A and B are 11 and 9 acres; the Deadwood plots 1 milacre. However, I can't help but wonder if an excess precipitation factor (as I've described it) might not provide a better estimate of storm runoff than the 30-minute intensity factor that Hawkins used. Sounds like intensity data might be good enough to calculate the excess factor for individual gages and then calculate a weighted factor for the entire watershed by the Thiessen or some other method.

We also tested a variety of antecedent precipitation factors including 1 day, 2 day, 5 day, and 5-day weighted precipitation factors. I don't remember the relative effectiveness of all these factors in reducing runoff variance not accounted for by excess precipitation, but the 5-day weighted antecedent precipitation was the best and reduced the runoff variance by a significant amount. This weighted factor consisted of weighting depth of precipitation earlier on the same day (as runoff) or on the first preceding day by one, on the second preceding day by 0.8, etc., to 0.2 for the fifth preceding day. Though this is arbitrary it does express, in a way, the lessening effect of antecedent precipitation with passage of time. We also found that as this antecedent precipitation factor increased there was a highly significant reduction in amount of sediment per unit of runoff. I suppose this might be a reflection of the fact that surface soil aggregates, crumbly and detached when dry, tended to coalesce and be more firmly held in place when wet. Anyway, I wonder how a weighted antecedent precipitation factor would look for Missouri Gulch in place of the 1-day antecedent precipitation depth or the 1-day antecedent streamflow.

Howard K. Orr

FLAGSTAFF

Beaver Creek Streamflow

Streamflow has been measured for the past several years on 14 watersheds in anticipation of treatments which will soon start on some of the watersheds. Treatments on the juniper watersheds will consist of juniper eradication followed by reseeding to grass; pine treatments will include thinnings and patch or strip cuttings of various intensities. The treatments will be evaluated in terms of their effects on water, timber, range, wildlife, and recreation. Annual water yield data through Water Year 1961 is summed up as follows:

BEAVER CREEK STREAMFLOW SUMMARY
WATER YEARS 1957-1961

Watershed number[1/]	Area	1957		1958		1959	
	Acres	Acre feet	Area inches	Acre feet	Area inches	Acre feet	Area inches
1	397	Incomplete		31.000	0.937	0	0
2	172			10.528	.735	0	0
3	468			30.837	.791	0	0
4	361	Incomplete		182.084	6.053	18.252	0.607
5	81	Incomplete		32.768	4.854	2.246	.332
6	125			Incomplete		.591	.057
7	2,046	Incomplete		927.806	5.442	16.440	.096
8	1,837	Incomplete		1,789.132	11.687	158.781	1.037
9	1,150	Incomplete		1,070.084	11.166	26.348	.275
10	550			Incomplete		8.203	.179
11	192			Incomplete		15.006	.938
12	502			Incomplete		7.280	.174
13	862					Incomplete	
14	1,431					Incomplete	

Watershed number[1/]	Area	1960		1961	
	Acres	Acre feet	Area inches	Acre feet	Area inches
1	397	20.586	0.622	5.302	0.160
2	172	8.450	.589	4.028	.281
3	468	23.944	.614	6.834	.175
4	361	152.539	5.070	35.761	1.189
5	81	23.371	3.462	6.261	.928
6	125	33.276	3.194	4.622	.444
7	2,046	497.920	2.921	85.586	.502
8	1,837	1,146.438	7.489	365.538	2.388
9	1,150	570.279	5.951	225.244	2.350
10	550	172.004	3.752	33.570	.732
11	192	77.205	4.825	9.573	.598
12	502	211.849	5.064	67.244	1.607
13	862	295.324	4.111	71.561	.996
14	1,431	509.312	4.271	112.443	.943

1/ Watersheds 1-3 are in the Utah juniper type at elevations of 5,100-5,400 feet, with annual precipitation of 13-25 inches. Watersheds 4-6 are in the alligator juniper type at elevations of 6,000-6,200 feet, with annual precipitation of 14-30 inches. Watersheds 7-14 are in the ponderosa pine type at elevations of 6,500-7,700 feet, with annual precipitation of 15-36 inches.

Following is an abstract of a paper now under preparation which describes recession flows from the Beaver Creek watersheds:

ABSTRACT. Characteristics of recession flows from small watersheds in a semiarid region.

Recession flows from 14 small watersheds in central Arizona are described and differentiated on the basis of watershed precipitation and vegetative cover. Recession flow is considered to be the flow which occurs between a seasonal or storm peak and the end of surface runoff. On these watersheds there is little if any ground water flow. The importance of recession flows is attributed to the fact that they account for a large proportion of the yearly runoff; also, it is expected that recession flows will be noticeably changed by certain proposed land treatments. Analysis is simplified by virtue of the fact that recession flows are less influenced by precipitation and temperature than rising flows. The recession hydrographs were appreciably different for watersheds covered with ponderosa pine, alligator juniper, and Utah juniper. During 4 to 6 years of record, recession flows from eight ponderosa pine watersheds lasted 1½ to 31 days following peak discharges of 14 to 56 c.s.m.; recession flows from three alligator juniper watersheds lasted 1¼ to 6¼ days following peak discharges of 19 to 93 c.s.m.; recession flows from three Utah juniper watersheds lasted 0 to 1¼ days following peak discharges of 0 to 55 c.s.m. Annual precipitation on the pine watersheds varied from 15 to 36 inches, on the alligator juniper watersheds from 14 to 30 inches, and on the Utah juniper watersheds from 13 to 25 inches. Hydrographs are plotted for each type of cover at different beginning peak discharges, and mathematical expressions are shown for typical recession hydrographs. Consideration is given to possible effects of land treatments on recession portions of the hydrographs.

Harry E. Brown

TEMPE

Prescribed fall burning of chaparral in Arizona

Chemical dessication and subsequent fall burning of chaparral in central Arizona resulted in significant reduction of crown cover and litter with as yet no resultant soil movement. Narrow strips on small (10 to 16 acres) drainages were sprayed on July 31, 1961, with 3 pounds acid equivalent Dinoxol (2,4-D-2,4,5-T) in 10 gallons diesel oil per acre. Leaf dessication, especially on Quercus turbinella, was rapid. The strips, comprising from 27 to 37 percent of the drainages, were burned on September 20, 21, and 22, 1961. The strips burned fairly well, and the fire was confined to the planned area.

Although living crown cover was materially reduced, enough litter was left to afford substantial protection to the ground surface. No sediment was moved into downstream retention dams built for this purpose.

Seedlings of desert ceanothus and manzanita, rare or absent before the fire, were abundant the following spring (table 1), although a protracted summer drought has reduced these to about one-tenth the number which originally germinated and emerged.

Table 1.--Response of chaparral vegetation and litter to planned fall burning.

	Living crown cover	Litter oven-dry	Total seedlings on 4,700 sq. ft. of sample plots	
			Desert ceanothus	Manzanita
		Tons/Acre		
Pre-burn	60.8	6.80	2	0
Post burn[1/]	4.5	4.85	232	74
Percent reduction	92.6	28.7	---	--

1/ May 1, 1962.

Charles P. Pase

Streamflow record reduction and analysis

Work has started on developing modifications to the 304-B computer program now used at Tempe, Arizona, for the reduction of streamflow data. The original program was tailored to fit the rating characteristics of some of our local gaging stations. A more versatile use may be made of 304-B system facilities of the General Electric Computing Center if the streamflow data reduction program is expanded to cover a wider range of gaging station characteristics.

A program for summarizing daily discharge volumes by water years is being given its first tests. Input to this program is from the magnetic tape output of the previously mentioned program. Output will also be on magnetic tape from which summary printouts can be made.

Paul Ingebo

Particle size characteristics of channel sediment and hillside soil

Sieve analysis of the material trapped in sediment basins and soil samples from the contributing slopes appear to be indicative of the sorting which has occurred during the channel movement of eroded material following the Boulder Mountain fire of June 1959. Immediately after the wildfire which caused nearly complete destruction of the chaparral cover on the Three-Bar experimental watersheds, large-capacity sediment basins were constructed below each of the four stream-gaging stations. At the time of each cleanout, samples were taken from the material deposited in those basins. During summer of 1962, samples were taken from undisturbed soils on two of the watersheds ("C" and "D") to a depth approximating that of the adjacent rills which had formed on the hillsides following the wildfire.

In the analysis, 1000 or 2000-gram aliquots of each field sample was shaken (dry) through a nest of standard sieves consisting of numbers 4, 8, 16, 30, 50, 100 and 200 sieves. Some samples contained a few rocks larger than one inch in diameter. These were removed and weighed but are not included in the data presented. The material retained on each sieve and that portion which passed the number 200 sieve was weighed separately and recorded.

Particle size distribution of the hillside and sediment basin material, based on the percent of the sample caught by each sieve, is shown in figure 1. These data represent the average values for 18 hillside samples and 22 sediment-basin samples collected in equal number from watersheds C and D. Statistical tests are to be made to determine if the apparent differences in the two sets of data are due to chance. Graphic analysis indicate that such will not be the case. Rather, we would suspect that significant amounts of the finer-sized particles from the two watersheds passed through the sediment basins as suspended material. As a consequence, the basin samples contain disproportionately high percentages of coarser material. The few hand-dipped samples we have obtained at high (but not peak-flow) stages, contained from 22 to more than 30 percent sediment by weight.

Suggestions of methodology, or results from similar studies would be appreciated. Should we hope that an analysis of data such as is here presented may be one way of determining the trap efficiency of specific sediment basins? And, can we come up with a tool for adjusting both sediment and water yield?

Paul Ingebo
George E. Glendening

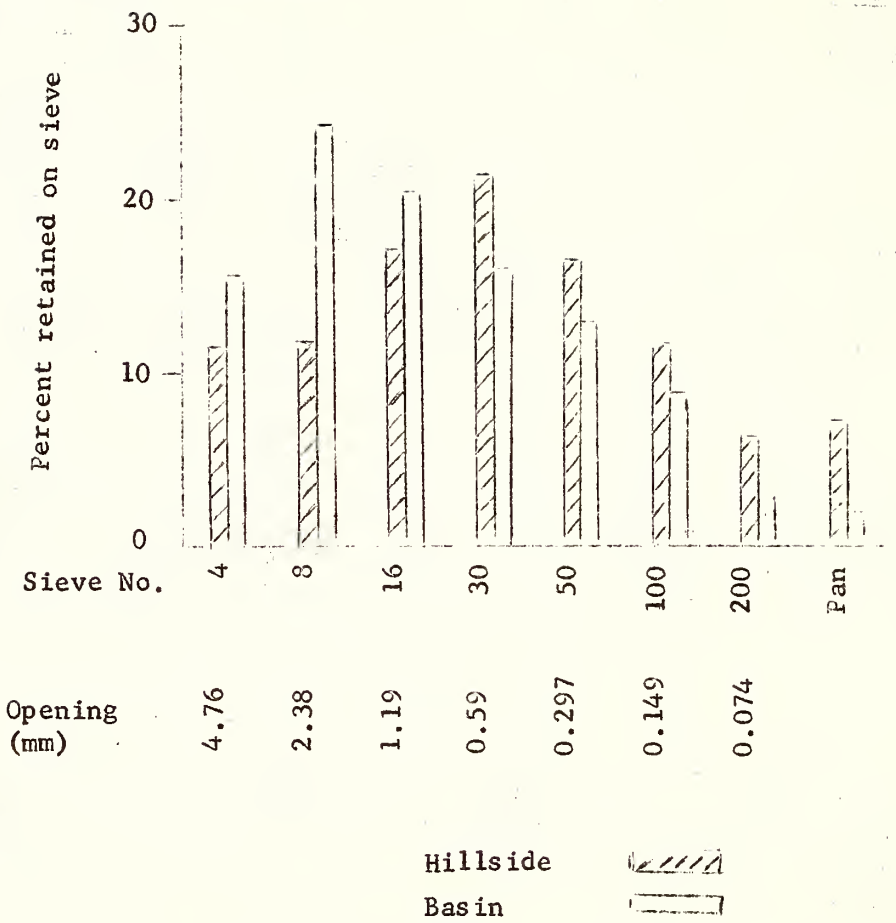


Figure 1.--Particle size distribution of hillside soil and transported material trapped in sediment basins.

Early evidence of treatment effect on streamflow

Evidence continues to mount that spraying of sprouting chaparral has resulted in a change in the streamflow relationships of Three-Bar Watersheds "C" and "D".

Mass plotting of both the monthly precipitation and monthly water yield of watershed "C" against "D" for the entire period of record (July 1956 - July 1962) has been done. The resulting data show that precipitation on "C" bears a near 1:1 ratio to that on "D", and that no change in slope of line has occurred. Streamflow plots toward the "D" side through September of 1961, then shifts noticeably toward the "C" axis. Watershed "D" has consistently had a higher unit area yield than "C"; but with only a week remaining in water year 1962, the current year's yield from watershed "C" greatly exceeds that from "D".

As was reported for 1961, diurnal change in streamflow on watershed "C" was again smaller than that on "D" during the dry summer of 1962. This was possibly the earliest sign of treatment effect following spraying of watershed "C" during May of 1960, 1961 and 1962.

A recent storm produced a single distinct peak in the hydrographs from both watersheds. These showed a peak discharge of 0.0318 c.f.s./A as compared with 0.0069 c.f.s./A from 0.84 and 1.04 inches of precipitation on watersheds C and D respectively.

With only three years data since the watersheds were burned by wildfire and only two years prefire data, a covariance analysis does not yet seem justifiable. However, the above signs appear to show us that a change in the water yield relationship of C and D has taken place.

George E. Glendening
Paul Ingebo

February snow melt on south slopes related to water yields

During February 1962, temperatures were higher than average and runoff from snowmelt occurred on the experimental watersheds at Workman Creek and Castle Creek. There was also a significant rise in Salt River. The one recorder well, maintained at 9,300 feet elevation during the winter, showed a good rise and the diurnal fluctuations were similar to the temperature curve, highest in the afternoon and lowest near midnight.

The daily peak streamflow in Salt River for February was 77 percent of the peak streamflow from spring snowmelt, 4180 c.f.s. daily discharge February 14, 1962, compared to 5400 c.f.s. April 17, 1962. The total daily flow in East Fork of Castle Creek (elevation 8000 feet) for February 16, 1962, was 79 percent of the maximum daily flow from snowmelt April 6, 1962. Maximum daily flow for February in North Fork of Workman Creek, (elevation 6800-7700 feet) was 92 percent of the peak flow from snowmelt which occurred March 28, 1962.

Snow mapping on Castle Creek and Workman Creek watersheds indicated that in both cases 100 percent snow cover was maintained on north slopes of both grass and timber throughout February. The breakup of the snow cover occurred in south slopes. On Workman Creek, snow cover was 100 percent throughout the watershed January 30, 1962. February 6, 1962, there was 100 percent snow cover on timbered south slopes but only 70 percent snow cover on south-slope grass areas. February 13, 1962, the snow cover had decreased to 50 percent on south-timber slopes and 30 percent on south grassland slopes.

Similar conditions were mapped on Castle Creek. North slopes maintained 100 percent snow cover throughout February 1962, but south slopes that were 100 percent covered February 2nd decreased to about 83 percent February 9th, and 52 percent February 16th which seems to indicate that the south slopes were important contributors to total water yields.

L. R. Rich

Effect of repeated clipping of tamarisk

A controlled clipping and regrowth study of tamarisk (Tamarix pentandra Pal.) was started near Tempe, Arizona, in March 1962. Previous studies concerning utilization of tamarisk by cattle indicated a need for more critical tests to determine if sprout removal can effectively reduce the growth and development of tamarisk.

The study is set up in a randomized block design and is being conducted in a mixed stand of tamarisk and arrowweed (Pluchea sericea Nutt.) Corville) within an enclosure. During the winter, all plants within the enclosure were chopped down, leaving a trunk eight to ten inches above ground level. A total of 200 tamarisk plants were used in the four treatments consisting of 50 plants each. The first treatment had all sprouts clipped at 2-week intervals; the second treatment, every 4 weeks; the third treatment, every 8 weeks, and the fourth, a single treatment in September.

At each clipping, length of the longest sprout on each plant and total weight of the clipped sprouts after air drying was recorded.

Preliminary data, listed in table 1, shows results of first season's growth. It would appear that only 26 percent of the plants in the 2-week clipping have survived, while 44 and 92 percent in the 4- and 8-week treatments, respectively, are still producing sprouts.

C. J. Campbell

Table 1.--Growth rates of Tamarix pentandra in the 1962 growing season after sprout removal treatments.

DATE	TREATMENT								
	2-Week			4-Week			8-Week		
	Foliage (grams) Air Dry Weight	Length (inches) Longest Shoot	Percent Survival	Foliage (grams) Air Dry Weight	Length (inches) Longest Shoot	Percent Survival	Foliage (grams) Air Dry Weight	Length (inches) Longest Shoot	Percent Survival
March 6	0.76	2.88	100						
20	0.37	2.30	100						
April 3	1.37	5.10	100	12.95	15.53	100			
17	9.16	10.99	100						
May 1	5.00	9.05	100	32.04	22.45	100	152.14	44.89	100
15	12.63	10.82	100						
29	6.20	7.30	100	29.33	19.04	98.5			
June 12	7.87	8.62	98						
26	3.38	5.88	94	16.50	21.58	83.5	124.77	39.34	100
July 10	2.75	6.21	88						
24	2.50	5.65	54	8.69	13.81	62			
Aug. 7	2.77	5.83	36						
21	1.76	6.14	26	7.11	11.96	44	38.09	22.76	92

C. J. Campbell

SEMIANNUAL REPORT

Division of Watershed Management Research
Southeastern Forest Experiment Station

April 1, 1962 - September 30, 1962

COWEETA HYDROLOGIC LABORATORY

Microclimate Relations

Shortwave Solar Radiation Record

Shortwave solar radiation (0.3 to 2.4 microns) has been recorded near the main weather station at Coweeta since July 1959 using the Belfort Instrument Company's pyrheliometer. Early operation difficulties were noted in the winter 1959-1960 and 1960-1961 issues of the Semiannual Report. Part of the record has been reduced to daily totals of radiation on a horizontal area by use of the USGS streamflow integrator, a fancy planimeter previously used for streamflow computations before our Oscar K chart reader was purchased.

Figure 1 shows the recorded solar energy receipt for 1961. The smooth curve represents the potential receipt if every day of the year was cloudless. The lower line represents the weekly means of recorded daily radiation receipt. The values in parentheses express recorded receipt as a percent of the potential receipt and are the numbers we use for estimates of percent of sunshine.

It is too early to say how well this one year represents the average conditions at Coweeta, but several generally noted but until now unmeasured conditions are shown. Spring and early summer was characterized by a higher percent sunshine than summer and early fall which are usually more overcast. The October dry period is quite obvious. As an overall annual average, the Coweeta Basin received in 1961 about 60 percent of the possible clear sky intensity.

Lloyd W. Swift, Jr.

Plant-Water Relations

Hardwood Defoliation

A number of forest management methods are known which increase streamflow by reducing evaporative losses; e.g., logging, burning, poisoning. These treatments are effective but usually expensive, sometimes hard to control and often destructive to timber, recreation and aesthetic values.

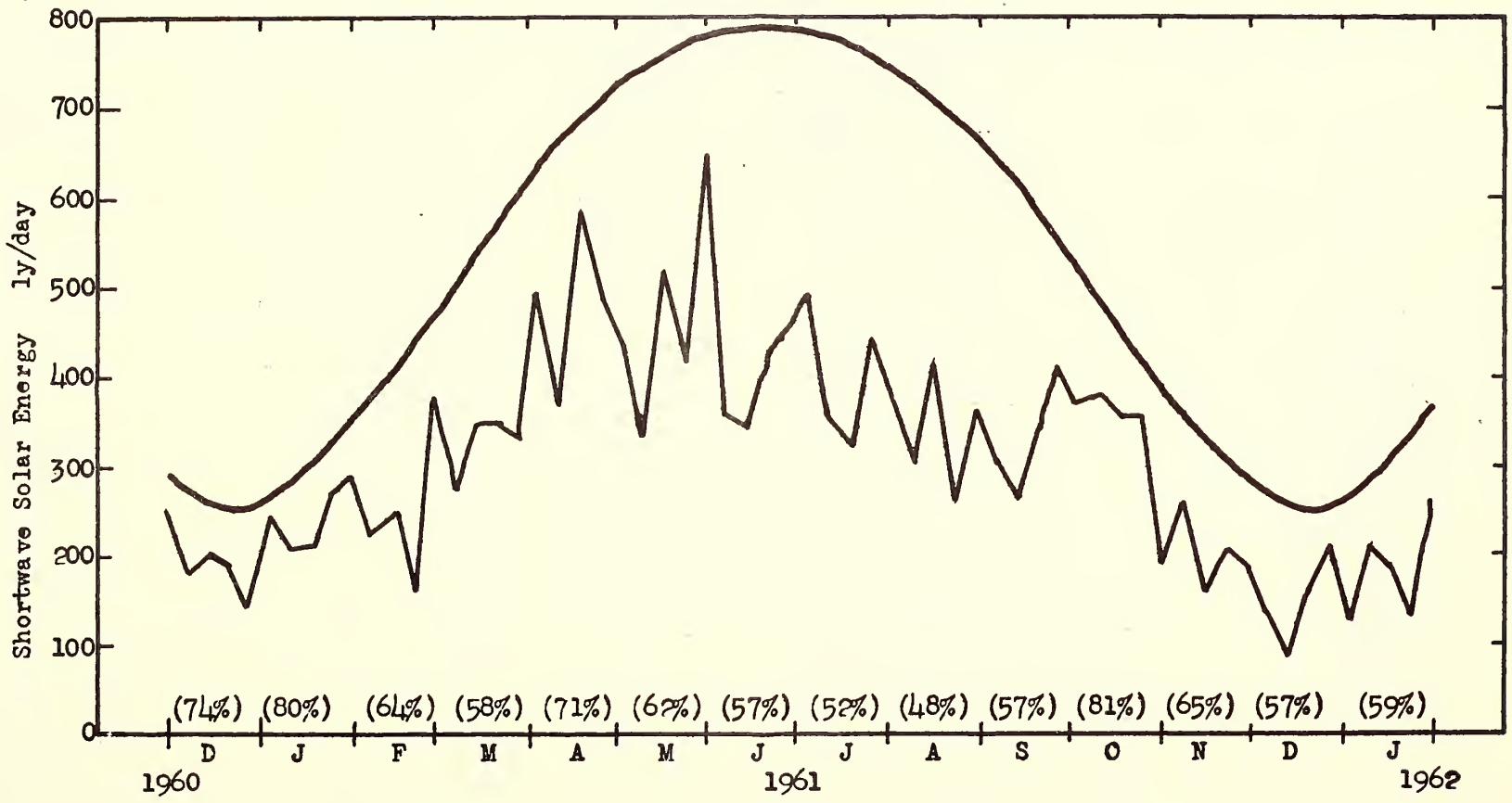

Shortwave Solar Energy ly/day
800
700
600
500
400
300
200
100
0
(74%)
(80%)
(64%)
(58%)
(71%)
(67%)
(57%)
(52%)
(48%)
(57%)
(81%)
(65%)
(57%)
(59%)
D
J
F
M
A
M
J
J
A
S
O
N
D
J
1960
1961
1962

Figure 1.

A method is needed to reduce midsummer evaporative losses from watersheds when evaporation, low rainfall and peak demands for water often occur simultaneously. Defoliation should temporarily retard transpiration, the major evaporative loss, and somewhat reduce interception while minimizing the unwanted side effects of attempts to kill all or parts of the forest cover.

Three plastic covered plots (see Semiannual Report, April - September, 1960) were used for comparing water use by fully leaved and defoliated mature forest trees. Foliage on all plots was allowed to develop naturally until late in June when tensiometers showed minimum tensions above .25 atmospheres in the upper 10 feet of soil. At this tension, drainage becomes negligible in these soils and further water loss can be attributed to transpiration. Two plots were sprayed with Dow General Dinitro weed killer, the third being retained as a control. A week later 99 percent or more of the foliage was dead. New foliage appeared in mid-July but even though few twigs were killed by the spray, regrowth has been scanty and slow, the new leaves small and delicate. Leaf regrowth apparently is related more to tree vigor than species, dominants having 15-25 percent of their original foliage while only 5-10 percent has regrown on small trees.

Since spraying there has been no measurable water loss from defoliated plots (Figure 2). During the same time transpiration has continued uninterrupted on the control plot, a water loss of almost 10 inches. Greater water savings might have been realized had the plots been defoliated sooner but drainage would have complicated that picture. Under conditions of this study, full foliaged trees used almost 5 inches of water per month during midsummer. Defoliated trees apparently used no soil moisture but it is possible that small quantities of water migrating laterally into the plots have compensated for minor use by the trees.

James H. Patric

Internal Water Balance of Forest Trees and Evapotranspiration (Summary of Dissertation)

The internal water balance of Cornus florida L., Quercus prinus L., Nyssa sylvatica Marsh., and Oxydendrum arboreum DC. was measured in natural forest under induced soil moisture stress. Three 50 by 50-foot plots were trenched and covered at the ground surface with plastic sheeting in a mature oak-hickory stand located in the humid climate of the southern Appalachian mountains. Soil moisture, atmospheric vapor pressure, and leaf-water deficits were measured from May to October both inside and outside the plastic covered plots. Soil moisture drought was found difficult to produce in deep soil under a humid

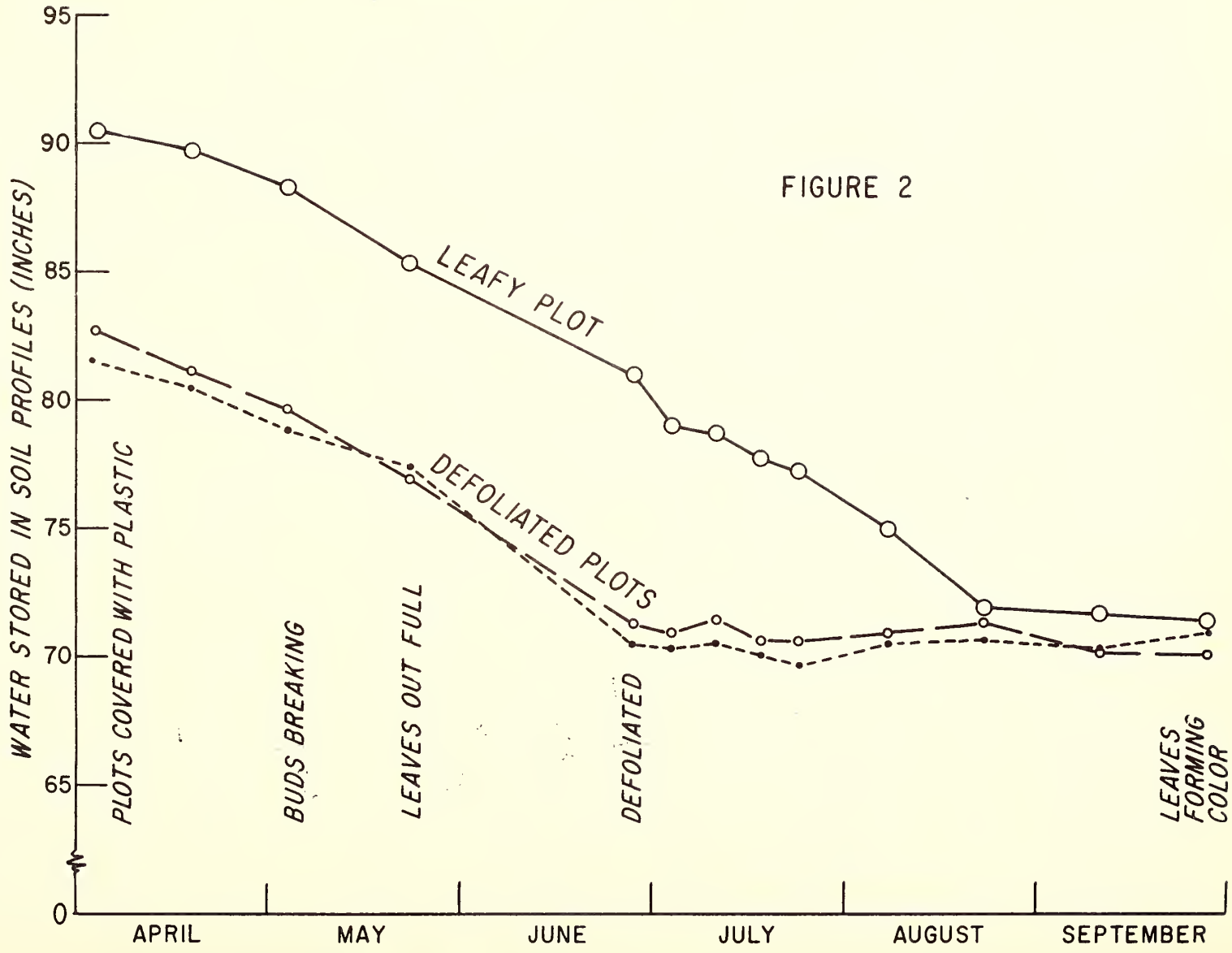

WATER STORED IN SOIL PROFILES (INCHES)
95
90
85
80
75
70
65
0
LEAFY PLOT
DEFOLIATED PLOTS
PLOTS COVERED WITH PLASTIC
BUDS BREAKING
LEAVES OUT FULL
DEFOLIATED
LEAVES FORMING COLOR
APRIL
MAY
JUNE
JULY
AUGUST
SEPTEMBER

FIGURE 2

climate, but definite responses to soil moisture tension between 0.3 and 2.0 atmospheres were produced in C. florida, Q. prinus, N. sylvatica, and O. arboreum, responsiveness decreasing in that order. C. florida, common to most eastern forest types, responded readily to changing environmental moisture stress, suggesting this species as a possible forest drought indicator for research and management purposes.

A survey of the literature reveals that methods for measuring and expressing leaf-water deficits have been very poorly devised and reported. Therefore each experimenter must develop, test, and fully describe his method before results can be evaluated.

The internal water balance was measured as leaf-water deficit by an improved whole leaf method and compared to the well known disk technique. Disks were found to indicate greater water deficits than really exist in intact plants because disks require more water to saturate than whole leaves. Stocker's "wasser defizit" (WD), when improved to permit shorter saturation schedules, remains the best method for determining and expressing water deficit in hardwood trees.

Forces causing water to move from soil through plants to the atmosphere were estimated. Soil moisture stress averages less than .4 atmosphere during the summer in the deep, forested soils of the southern Appalachian highlands. Water deficit in C. florida during the summer averages less than 6 percent WD, equivalent to about 5 atmospheres diffusion pressure deficit. Under an average solar energy receipt of 400 gr cal/cm^2 (langleys) per day, vapor pressure gradients from leaf to air at 2:00 p.m. appear to average .008 atmosphere and seldom exceed .017 atmosphere.

Transpiration from the upper 18 feet of soil inside the plastic covered plots reached an average of .105 inch per day during June and July, when soil moisture tension was generally less than 1 atmosphere. Growing season transpiration, based on neutron meter determinations in isolated plots, probably accounts for no more than 50 percent of annual evapotranspiration as estimated by the water balance at Coweeta.

Although its relation to transpiration rate is not yet clear, measurement of WD is a quick method for assessing the internal water balance of a tree or a forest. Routine measurement of WD in forest research will lead to better understanding of the transpiration of forests.

John D. Hewlett

Soil-Water Relations

The Slope of Neutron Meter Calibration Curves

Get two users of neutron equipment together and talk turns to calibration curves. As often as not, the manufacturer's curve appears not to apply in a given area, and the user constructs his own curve. The need for

recalibration is obvious--soils are different. But, has the user gained accuracy by the recalibration? I suspect not in many cases because gravimetric calibration fails to account for two important factors which affect counting rate: 1) differences in the amount of hydrogen retained by soils after drying, and 2) differences in neutron absorbers between soils.

Soils vary in the amount of hydrogen remaining after drying, depending on mineral characteristics and texture of the soil. Tightly bound water also slows neutrons, and since tightly held water is positively related to clay content, gravimetric curves derived from soils of variable texture contain a bias. Even if a drying temperature which removed all water could be selected, differences in neutron absorbers would still be a problem.

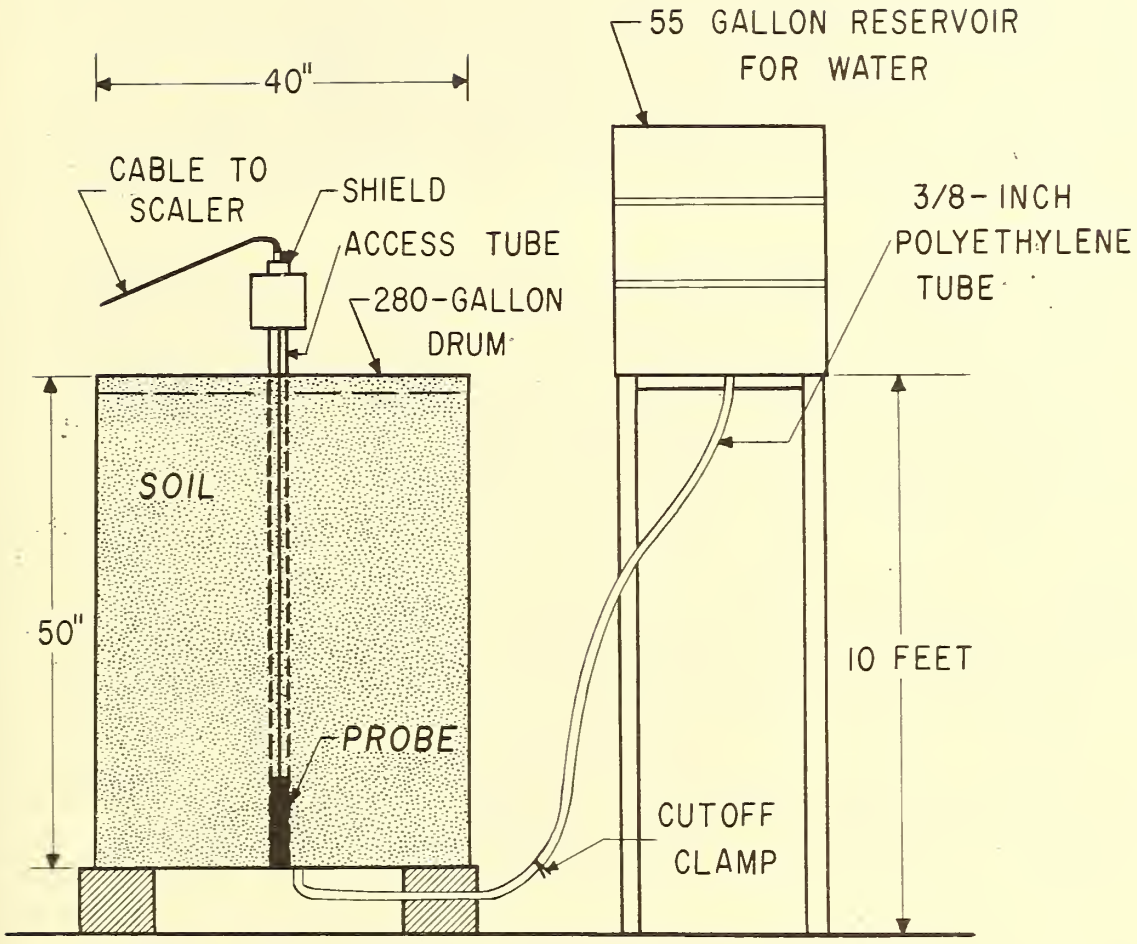
Neutron count recorded by the scaler measures the equilibrium existing between slow neutron production and absorption by the soil. Absorption is related to the mineral make-up of soils, and as mineralogy changes, relative absorption efficiency may also change. Absorption has been assumed to be fairly constant between soils (except those containing large amounts of lithium, boron, etc.), but there is evidence to the contrary. As yet, however, there is no satisfactory means of measuring the effect of absorption on counting rate.

Because the slopes of gravimetrically derived calibration curves are open to suspicion, a method was devised to check the b coefficient experimentally (Figure 3). It involves measuring the count change which occurs when a known volume of soil is changed from a given moisture content to saturation by addition of a measured volume of water. The advantages of the method are that the b coefficient is independent of tightly bound water and that differences in b coefficients between soils reflect absorption differences. Coefficients obtained by this method were compared with b coefficients from the manufacturer's curve and a gravimetric curve for piedmont soils. Results indicate that both calibration curve b coefficients were incorrect and that the slope of Appling sand and Cataula-Lloyd clays differed by about 17 percent. Surprisingly the b coefficient of the manufacturer's curve was in error less than the gravimetric curve derived from local soils.

The method of determining the slope of neutron meter calibration curves is to be published as a Station Paper. Meanwhile, a limited number of mimeographed copies are available for those interested in the calibration problem.

James E. Douglass

FIGURE 3


55 GALLON RESERVOIR
FOR WATER
40"
CABLE TO
SCALER
SHIELD
ACCESS TUBE
280-GALLON
DRUM
3/8-INCH
POLYETHYLENE
TUBE
SOIL
50"
PROBE
10 FEET
CUTOFF
CLAMP

Streamflow Relations

Barometric Pressure and Temperature Related to Ground Water Fluctuations

Reference is made to the report by Sartz and Curtis (Semiannual Report ending March 1962, page LS 11) in which fluctuations in springflow are related to barometric pressure. The phonomenon has attracted attention for a long time. Baldwin Latham reported at the British Association for the Advancement of Science in 1881 and again in 1883 his observations and experiments in England on the effect of barometric pressure on ground water levels and flow from springs and an artesian well. The cause of these fluctuations he attributed to the expansion and condensation of air and gases held by the water, which at a period of low barometric pressure have a tendency to expand and so facilitate the flow of water, while the reverse occurs under the conditions of high barometric pressure.

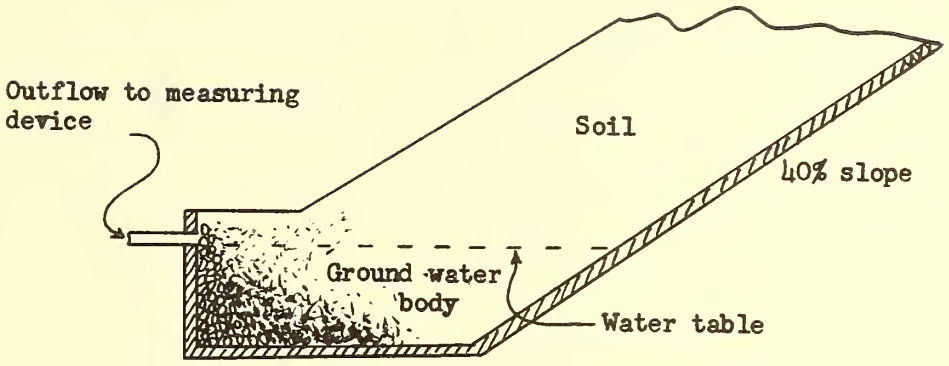
At Coweeta, outflow from an inclined soil model began to show double diurnal fluctuations after about 20 days of drainage. A large increase in outflow occurred in early afternoon and a smaller increase just after midnight. The general outflow level likewise fluctuated with major changes in barometric pressure associated with local weather conditions, much as noted by Sartz and Curtis. The soil column, 3 x 3 x 45 feet long, was sloped at 40 percent with its lower end intersecting a water table maintained at a fixed level by an outflow pipe (Figure 4a). A daily temperature rise of 1° to 2°F in the top 2 inches of soil was found to be closely correlated with the early afternoon increase in outflow, but at night the temperature steadily decreased during the second peak in flow (Figure 5). A recording microbarograph showed slight drops in barometric pressure at about noon and again shortly after midnight to be normal daily occurrences.

We postulated that the combined effect of temperature rise and pressure drop caused gases within the ground water body to expand, thus increasing waterflow at the outflow pipe. The night peak appeared to result solely from the nightly pressure drop.

To test this hypothesis we cut a 55-gallon steel drum into and necked the open end to an 8 inch standpipe (Figure 4b). The container was then loaded with gravel, sand, and soil to form an artificial "ground water body" similar to the base of the soil model and then filled it from the bottom until water stood in the narrow standpipe. The entire system was well insulated to hold temperature constant. Changes in volume of the contained water was measured by a water level recorder.

Figure 6 shows how closely an increase in volume follows a drop in pressure and vice versa. Note that the minor (twice daily) pressure changes, as well as pressure changes associated with major climatic events, caused the volume to expand and contract. It was concluded

a


Outflow to measuring device
Soil
40% slope
Ground water body
Water table

b

FIGURE 4

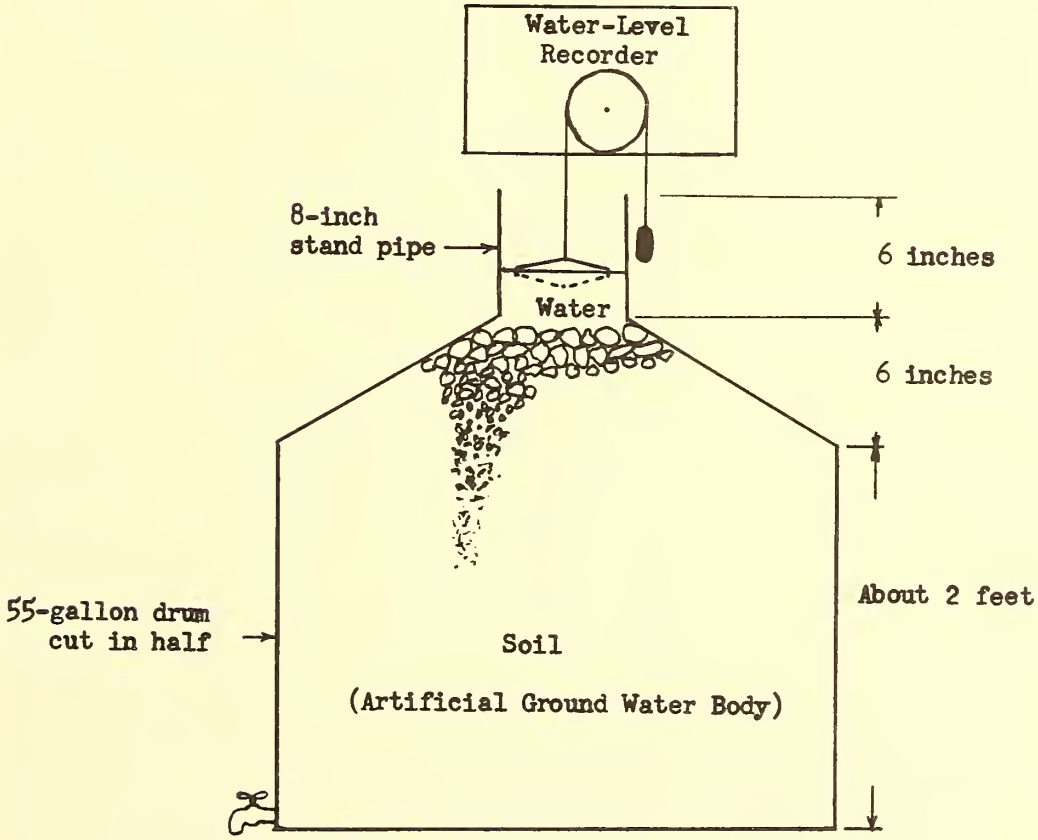
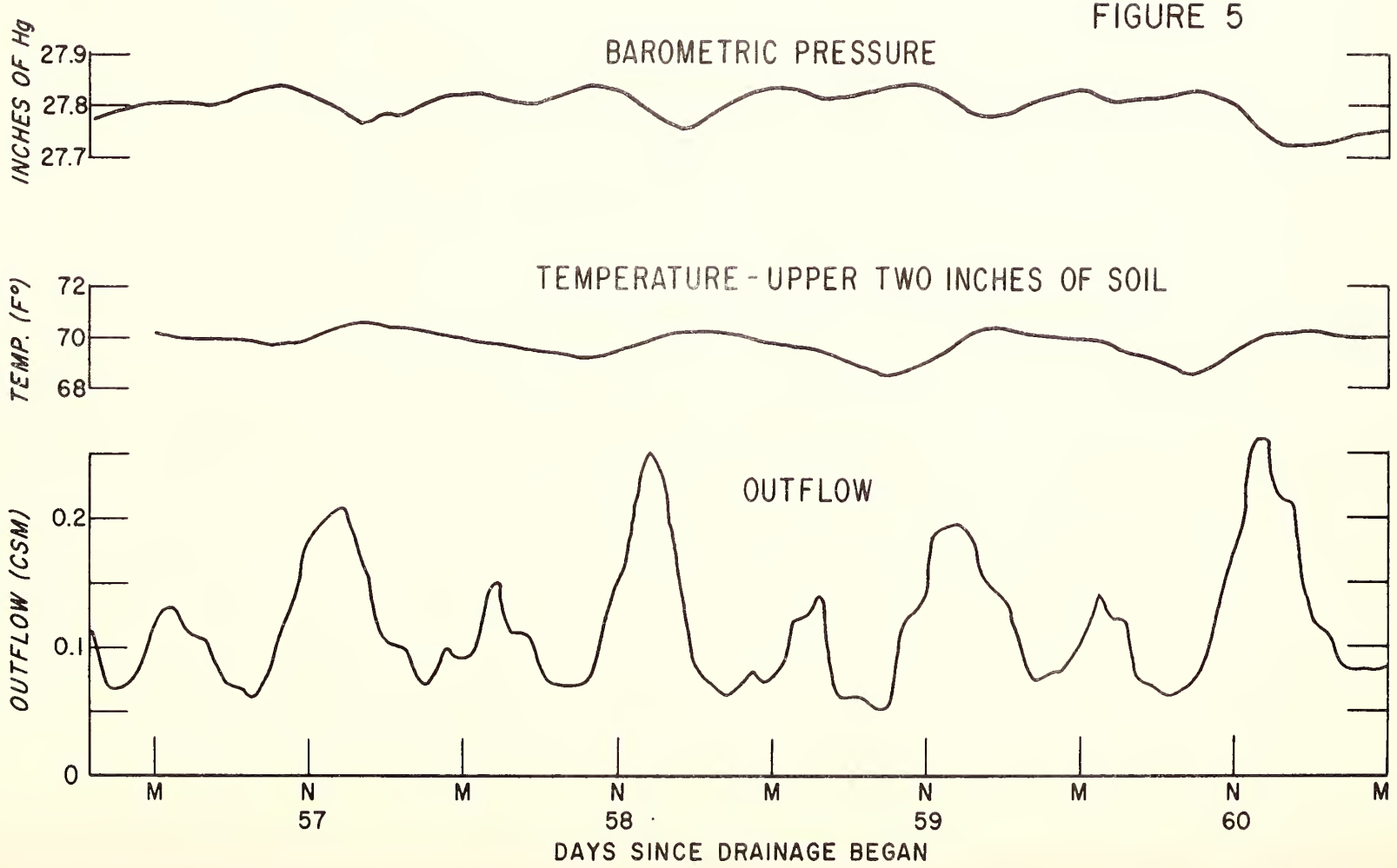

Water-Level Recorder
8-inch stand pipe
6 inches
Water
6 inches
About 2 feet
55-gallon drum cut in half
Soil
(Artificial Ground Water Body)

FIGURE 5


BAROMETRIC PRESSURE
INCHES OF Hg
27.9
27.8
27.7
TEMPERATURE - UPPER TWO INCHES OF SOIL
TEMP. (F°)
72
70
68
OUTFLOW
OUTFLOW (CSM)
0.2
0.1
0
M
N
57
M
N
58
M
N
59
M
N
60
M
DAYS SINCE DRAINAGE BEGAN

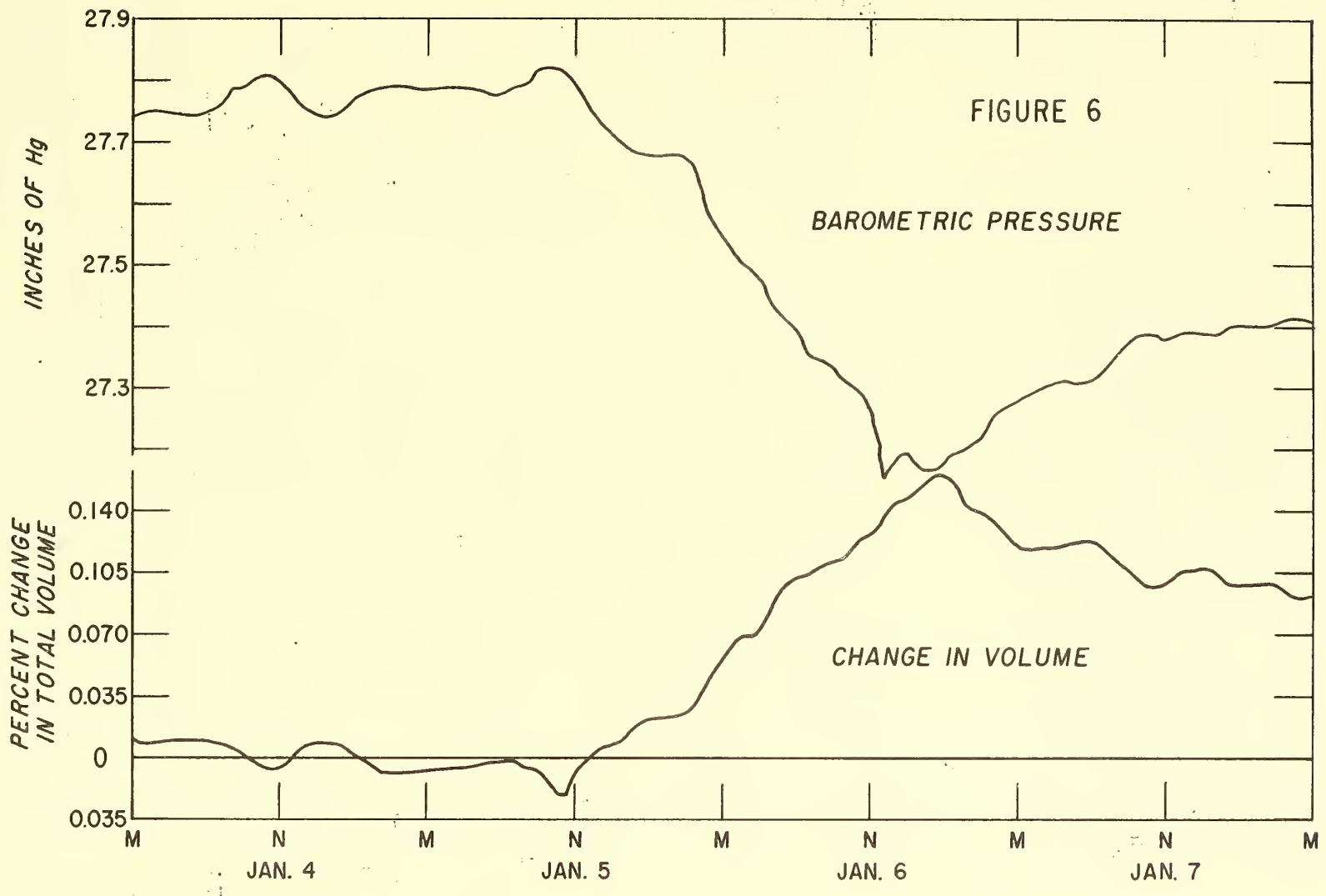

27.9
27.7
27.5
27.3
INCHES OF Hg
BAROMETRIC PRESSURE
0.140
0.105
0.070
0.035
0
0.035
PERCENT CHANGE IN TOTAL VOLUME
CHANGE IN VOLUME
M
N
M
N
M
N
M
N
M
JAN. 4
JAN. 5
JAN. 6
JAN. 7

FIGURE 6

that barometric pressure and temperature changes, each functioning independently by Boyle's Law, were the major causes of fluctuations in outflow from the soil model.

Can fluctuations in springflow be explained in a similar manner? Even though water is considered relatively incompressible we know that cool ground water contains some gases, especially at and near the water table, and these gases can be expected to expand and contract under atmospheric pressure changes. These expansions and contractions may be great enough to change flow gradients in the immediate vicinity of the springhead and thus account for the observed flow fluctuations. Temperature effects on the system may also be important, although most ground water bodies are insulated from rapid temperature changes.

Alden R. Hibbert

Discussion

In the belief that professional identification within a scientific field favors technical progress, I would ask whether watershed research is weakened by our diffuse attitudes toward the science of hydrology. Personally, I would rather see our division called Forest and Range Hydrology, and an occasional sprinkling of hydrologist listed among the research foresters, plant physiologists, soil physicists, and so on. Whether the title hydrologist, or a change in division names, are recognized as desirable or not, I believe our research, our thinking, and the scope of our work would be sharpened by a clearer focus of the scientific area within which watershed research is performed.

The question is do we identify ourselves as foresters, botanists, soil scientists, and meteorologists generally, but only as hydrologists when we go to the AGU meetings? Do any of us really claim to be hydrologists Most of us this year received the usual questionnaire from a national registry requiring identification of our work in the areas of biology, forestry, hydrology, geophysics, and so on. These forms are a bit of a puzzle to those who call themselves "watershed management researchers," if anyone does. For instance, the technical specialties list covers watershed work in at least three broad areas as well as in many additional narrower ones. Clearly, there are aspects of watershed management research within forestry, hydrology, and geophysics, as well as in botany, meteorology, soil science, and hydraulic engineering. Watershed management research is an exceedingly vague term and one wonders what it embraces that wouldn't be included better in the terms Forest or Range Hydrology. Waldo Smith recently wrote that "hydrology is the science of the occurrence, behavior, and disposition of water in all its forms on and in the land areas of the earth." Our efforts would appear to fit clearly within hydrology thus described. Considering the fact that all our work in one way or another deals with water, watershed management research perhaps has a better focal point than most interdisciplinary fields of research. Why then do we seem to avoid the term "hydrology"?

John D. Hewlett

CHARLESTON WETLAND IMPROVEMENT PROJECT

The Charleston Wetland Project (studies of coastal plain hydrology and the effects of controlled drainage on soil productivity and wildlife habitat) is now well underway after a period of gearing up for the much-needed research. It is estimated that there are about 18 million acres of forest throughout the Southeastern coastal plain states of Virginia, North Carolina, South Carolina, Georgia, and Florida in the wetland category. Close to 12 million acres out of the 18 are bottomland hardwoods and cypress; the remaining 6 million acres are wet pine and pine-hardwood areas which are believed to have a high potential for water, wildlife and timber production through improved soil-water management.

Presently, many forest landowners have projects underway or planned to lower natural water levels through drainage to enable the establishment of loblolly, slash or pond pine plantations. However, very little is known about the water transmissibility of coastal plain soils to guide the design of drainage systems, the soil changes which occur after drainage, the amount of water surplus to the water economy, or the hydrologic effects upon areas lying beyond the location of immediate benefit.

Studies of the effects of drainage on the water regime and on tree survival and growth are already underway at two locations. This work will be expanded to include a greater range of soil conditions and more detailed measurement of drainage effects on both the soil and water systems. Additional research is planned which will attempt to classify wetland sites on the basis of their hydrologic characteristics, identify the major surface and subsurface features affecting coastal plain hydrology, investigate the operative components of the hydrologic cycle, and document changes in wildlife habitats caused by alteration of the natural water regime.

Water Table Drawdown on Drained Wetland Forests

Wet slash pine flatwoods with deep sands have been drained on a pilot basis on the Apalachicola National Forest, Florida. For the past year and a half, the Charleston Research Center, in cooperation with the Florida National Forests, has been studying water table drawdowns following drainage.

Preliminary results to date are summarized as follows:

(1) It is not unusual for the water table to remain three feet or more below ground surface for any month of below average rainfall.

(2) Surface flooding is no longer a problem as water seldom if ever stands on the surface.

(3) Four-foot deep drainage ditches exert definite internal drainage effects 300 feet from the ditch during periods when the water table is within a foot of ground surface and 500 feet when the water table is 2 feet or deeper.

Plant-Water Relations

The Charleston Research Center, in cooperation with the West Virginia Pulp and Paper Company, installed a study in 1961 to study the plant-water relations of five coastal plain species (loblolly pine, baldcypress, sweetgum, swamp tupelo, and water tupelo)on drained wetlands near Summerville, S. C. Research plots were located over a range of soil and water conditions and the above mentioned species were planted on all plots. Water table readings provide a seasonal and annual march of water conditions.

Preliminary results of the first growing season are summarized as follows:

(1) Height growth of baldcypress and water tupelo were positively correlated with average water table levels during the growing season.

(2) Excessively high or low water levels retarded swamp tupelo growth.

(3) Height growth of loblolly pine and sweetgum were negatively correlated with average water table levels during the growing season.

(4) Average water table levels for the 1961 growing season ranged from 0.34 feet above to 1.84 feet below ground surface.

Ralph A. Klawitter
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SOUTHERN FOREST EXPERIMENT STATION
Watershed Management Research Semiannual Report

April - September 1962

General

On July 1, Watershed Management Research was reorganized on the basis of the new project assignments. Project Leader assignments are as follows:

Harrison, Ark.
Water Timing in Ouachita-Ozarks - A. W. Krumbach

Oxford, Miss.
Coastal Plain Hydrology - Stanley J. Ursic
Watershed Rehabilitation - Douglas C. McClurkin
Management of Erosive Watersheds - Hamlin L. Williston

During the six-month period, much effort has gone into completion of work which will not carry over into the new program, and to planning and organizing work under the new projects. In June, Krumbach, Ursic, McClurkin, and Stephenson visited watershed research installations at Coshocton and New Philadelphia, Ohio, Parsons, West Virginia, and Franklin, North Carolina. The trip was very helpful for the contacts with research personnel, the opportunity to see and discuss instrumentation and techniques, and a firsthand look at soils and situations under study.

Oxford Research Center

Bulk Density Under Pines

On an area of very compact soil, bulk density under 10-year-old pines was compared with that on plots with no vegetative cover. Measurements were made with a gamma ray density probe, and related to root volumes in soil samples taken at the same points. No statistically significant relationships were found.

This contrasts with a comparable study where a grass cover had significantly reduced bulk density in the upper foot of soil. Possibly the decay of short-lived grass roots left unoccupied root channels, while more of the pine roots have persisted so that their channels have not greatly affected bulk density.

Soil Moisture and Radial Growth

Dendrometers on cypress, white ash, and sweetgum trees have been read twice weekly since 1959. Ground water wells on all plots, and soil moisture units on one, were read concurrently.

Ash started diameter growth earlier and stopped sooner than the other species; growth of sweetgum and cypress started late but was steady throughout the growing season. Thinning has increased growth of ash, but not sweetgum. The study will run another year before growth-water relationships are to be determined.

Species for Adverse Sites

Four geographic seed sources of loblolly pine are being tested, two shortleaf, and one each of Virginia and sand pine. Fifth year results are as follows:

Species and seed source	Survival		Height growth	
	Sandy sites	Eroded sites	Sandy sites	Eroded sites
	Percent		Feet	
Lost Pines--Caldwell Co., Tex.	97.0	81.5	12.02	8.12
Loblolly--Cherokee Co., Tex.	94.7	79.7	10.59	6.20
Loblolly--Northwest Georgia	91.9	87.1	9.99	6.43
Loblolly--Crossett, Ark.	91.8	70.6	9.05	5.73
Sand Pine--West Florida	70.4	75.3	8.74	4.48
Virginia Pine--East Tennessee	87.4	83.7	7.37	4.72
Shortleaf--Lafayette Co., Miss.	89.1	75.9	6.32	3.78
Shortleaf--McCurtain Co., Okla.	84.3	80.5	6.88	3.54

Differences in growth between loblolly and the other species was highly significant. Among the loblolly differences between the Lost Pines and the other sources were highly significant after the second growing season and continued to increase through the fifth season. There were no real differences between Cherokee County, Texas, and northwest Georgia sources but there was a highly significant difference between these two sources and the Crossett source. There were no differences in survival between loblolly sources.

There were no differences in height growth between sand pine and Virginia pine, but the differences in survival were highly significant. Sand pine was the only pine to have a higher mortality on sandy sites.

There were no differences between the two shortleaf sources in growth or survival but highly significant differences in growth between these sources and the average of the Virginia and sand pine.

The effect of site on both survival and growth was highly significant.

Kraft-Polyethylene Bag Storage

1-0 Loblolly seedlings packed in K-P bags with and without moss, and with Rutex spray, were held on warehouse racks and in cold storage for 1.5 and 9 weeks.

Heavy Rutex applications were detrimental, and a lighter spray was not beneficial. All other treatment combinations resulted in satisfactory survival and growth. Cold storage was best, especially for seedlings packed without moss, but excellent results were also obtained with rack storage when seedlings were packed in moss as in standard Forest Service bales.

Harrison Research Center

Forest to Range Conversion

Changes in the surface 3 inches of soil were studied on Ozark woodland pastures sprayed with silvicide and variously grazed for four seasons. Infiltration rates, detention and retention storage, bulk density, particle-size distribution, and water-stable aggregateswere determined in 1957 and 1961.

Results:

1. Grazing at the indicated levels did not cause significant changes in physical soil properties.

2. Infiltration rates were found to be significantly less on sprayed areas than on unsprayed woodlands.

3. Some breakdown of soil aggregates occurred on the sprayed areas, when compared to unsprayed areas.

In other physical properties, there was little change that could be attributed to woody stem removal or grazing.

Publications

In Print

Bower, D. R., and Smith, J. L. 1962. Seedbed burns in Arkansas mountains compact surface soil. U. S. Forest Serv. South. Forest Expt. Sta. South. Forestry Notes 139.

Koshi, Paul T., and Stephenson, George K. 1962. Shade and mulch as influences on loblolly seedlings and their immediate environment. Soil Sci. 8(2): 191-204, illus.

Krumbach, A. W., Jr. 1962. Power sampler for frozen soil. Soil Sci. Soc. Amer. Proc. 26(2): 209, illus.

McClurkin, D. C. 1962. Good survival of nondormant loblolly pine seedlings. U. S. Forest Serv. Tree Planters' Notes 51, p. 10, illus.

Smith, James L. 1962. Rocky soil sampling and analyses. Jour. Soil and Water Conserv. 17(2): 71.

Thames, John L. 1962. Litter production as influenced by species of southern pine. Jour. Forestry 60(8): 565, illus.

Ursic, S. J. 1962. Early survival of loblolly plantings on eroded lands. Tree Planters' Notes 53, pp. 27-28.

Williston, H. L. 1962. Loblolly pine seedlings survive twelve days' submergence. Jour. Forestry 60(6): 412.

Submitted:

Bassett, John R. Influence of soil properties on site index of pine. Submitted to LSU Agronomy Dept. April 13, 1962.

McClurkin, D. C. Soil-site index predictions for white oak in north Mississippi and west Tennessee. Submitted to Forest Science May 21, 1962.

Thames, John L. Seedling size and soil moisture affect survival of loblolly pine sprouts. Accepted by Tree Planters' Notes July 17, 1962.

Thames, John L. Loblolly best but seed source important in erosion control in north Mississippi. Accepted by Tree Planters' Notes June 1, 1962.

Ursic, Stanley J. Modifications of planting technique not recommended for loblolly on eroded soils. Accepted by Tree Planters' Notes July 18, 1962.

LOAD CELL PENETROMETER

John L. Thames

A soil penetrometer employing a small pressure transducer is currently being tested at Oxford. It shows promise of high accuracy at low cost. Disassembled it can be carried in a hip pocket. It may be hand held for instantaneous readings or mounted and connected to a recorder for more detailed information.

The transducer consists of a thin layer of pressure sensitive paint[1/] sealed between two 3/4 inch brass discs. The paint changes electrical resistance with force. The changes are nearly logarithmic, quite reproducible, and can be read with any good volt-ohmmeter.

The transducer is mounted in the end of a 2-inch long cylinder. The action of a piston within the cylinder provides the force. The cell can be pre-loaded to any desired point by tightening a knurled ring which is threaded on the base of the cylinder and bears against the piston. Calibration is a simple matter of loading the unit and observing meter deflectings.

The unit is readily adaptable to other measurements of force or weight particularly in the field, but needs further testing to check temperature effects, zero drift, and longevity.

1/ Transducers and pressure sensitive paint can be obtained with force ranges covering grams to tons from the Clark Electronic Laboratories, Palm Springs, California.

THE STORM AS THE UNIT EVENT FOR CALIBRATION OF SMALL WATERSHEDS

S. J. Ursic

The discussion, "Wanted--Shorter calibration periods," by Nedavia Bethlahmy in the October 1961-March 1962 Semi-Annual Report (PNW 7-10) was of particular interest to Oxford personnel who are using similar techniques for calibrating small (2- to 5-acre) watersheds with ephemeral flow characteristics in north Mississippi.

Consider watersheds A and B, both long-abandoned cotton fields supporting a native cover of grasses and forbs. Total runoff for individual storms was selected as the principle criterion for pre- and post-treatment comparisons. Regression coefficient of separate linear regressions for 5 years (1957-1961) range from 0.905 to 1.155; correlation coefficients 0.889 to 0.996. Covariance analyses reveal that data for 1957 and 1958 must be excluded from a pooled regression, confirming indications from a double-mass curve that the relationship between watershed A and B was changing during the calibration period. The changing relationship could easily have been overlooked if calibration was based on annual values.

The correlation coefficient for the pooled data (1959-1961) is 0.977. Fiducial limits (one-percent level) around the regression line define departures from predicted values which must be exceeded to detect changes in storm runoff resulting from watershed treatment--in this example, departures greater than 10 percent for amounts of runoff between 0.18 and .25 inches, and greater than 8 percent for runoffs exceeding 0.25-inches.

Additional relationships including instantaneous peak flows and time to peaks will be attempted to more fully evaluate changes in flow characteristics resulting from treatment. Annual post-treatment regression coefficients will be compared to the pooled pre-treatment coefficient to detect changes with time. Comparisons will also be made for all potential flood-producing storms.

The analyses illustrate that storm runoff is sensitive to minor changes in vegetation. Cover conditions improved on both watersheds during the calibration period but at a faster rate on watershed A. This was due in part to the removal of scattered hardwoods, mostly blackjack oak. Watershed A had more hardwoods and, because the litter did not accumulate, more bare areas after cutting. The greatest changes occurred during the first two years. This was evident from observations, photographs, and remeasurements of permanent line transects. Future changes are expected to be slight.

The researcher at this point has two choices-- to extend the calibration period for one or two years to determine whether or not the regression coefficients are still changing or to treat watershed B. The latter seems preferable, for in addition to eliminating additional costly calibration, it is also conservative. Treatment effects would have to overcome the possible more rapid natural improvement on the control watershed. This assumes that watershed treatment will reduce storm runoff. Conversely, treatments anticipated to increase runoff would be applied to watershed A, although in this situation there may be a stronger case for additional calibration depending on the nature of treatment.

Use of the storm as the unit event shortens the calibration period and provides information not afforded by annual values. Calibration periods for watersheds with forest covers should seldom have to exceed three years. Changes occurring during the calibration period can be detected and may be of as much interest as the post-calibration treatment. A final advantage is that missing storms or those with questionable or incomplete traces do not have to be estimated to complete the annual record. They are simply omitted.